Bocconi

Screening the efficiency of packaging waste in Europe

In collaboration with

CONAI
CONSORZIO NAZIONALE IMBALLAGGI

Università Bocconi
GREEN
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We acknowledge the valuable contributions that Amanda Fuso Nerini (CONAI) and Joaquim Quoden (EXPRA) have made to this study and to the underlying analysis.

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General Executive Summary

The project "**Screening the efficiency of packaging waste in Europe**" has been promoted by Consorzio Nazionale Imballaggi (CONAI) with the support of the Extended Producer Responsibility Alliance (EXPRA). The project assesses the performance of different packaging waste Extended Producer Responsibility (EPR) systems across Europe, with a focus on the activities conducted by the Producer Responsibility Organizations (PROs). An econometric analysis and an indicator-based assessment are adopted to provide a quantitative analysis of the **cost efficiency** and **effectiveness** of **25 Member States'** EPR systems and **21 PROs**. Furthermore, though an ad-hoc survey collecting data from more than 20 European PROs, the project evaluates the coherence of **PROs' tariff schemes** in relation with the environmental goals of waste packaging management.

The primary result of the research is that PROs' **recycling effectiveness is not necessarily associated with high EPR systems' costs**. Through the indicator-based assessment we identify a group of PROs that is both more effective in recycling and cost-efficient than the European average (Figure 1). Though the econometric analysis we assess the impact on the recycling rate of the EPR schemes' characteristics, of the National waste management system and of macroeconomic conditions. We find that PROs that operate with a shared responsibility through a unique, non-competitive system **achieve,** on average and *ceteris paribus*, a **recycling rate of total packaging 8 percentage points higher** than systems that operate in competitive environments with multiple PROs. **Financial resources are used more efficiently in the former group**, although results vary greatly by material and a particularly low performance across all EPR categories is found as for plastic packaging when EPR costs are below the European average. Furthermore, we find that across all packaging materials, **higher recycling rates are expected when local authorities are involved** in the operational responsibility of collection. The analysis based on the survey's responses finds that **EPR fees' modulations is mostly based on qualitative and operational criteria**, rather than on the recyclability of materials or the share of recycled materials used in packaging production (the latter are adopted in 20%-30% of the cases). This result shows that there is still **a large untapped potential for PROs to foster a more circular path** for the packaging waste production.

Our empirical findings support the hypothesis that unique, non-competitive system can benefit from a range of different aspects that may include: optimization of logistics and processing costs from a homogeneous territorial distribution, reduction in administrative burdens, more effective communication between actors, avoidance of opportunistic behavior. At the same time, it is important to underscore that the restrictions and entry barriers characterizing non-competitive

systems must be carefully assessed when the system is launched, and that monitoring should be effectively implemented.

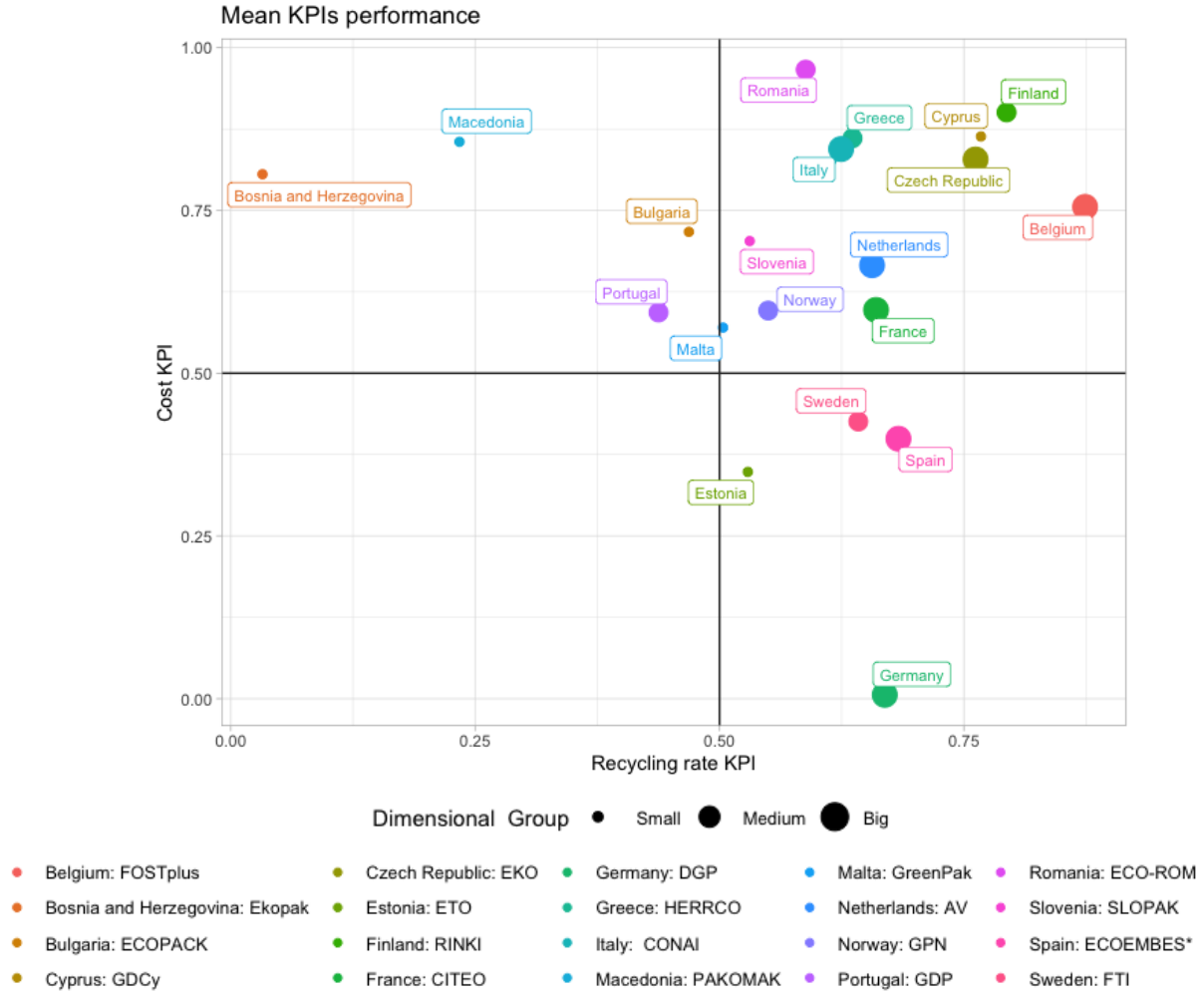


Figure 1: The Figure shows the mean of the normalized score in the KPIs, collected from 2014 to 2019. The following packaging materials are included for the computation of the overall score: plastic, paper, wood, metal, glass. Data for Spain includes the performance of ECOEMBES and ECOVIDRIO, while for Belgium includes FORST-Plus and Valipac (the KPIs disaggregated by these PROs is presented in the Annex II, Table S2). Data for DGP is limited to the years 2017-2019. The full list of PROs' acronyms is reported in the Annex I.

Although several PROs shared their data openly and with engagement, we find that a comprehensive disclosure on operational results and costs is generally lacking across Europe. Economic assessments of EPR systems across Europe will greatly benefit from an **improvement of transparency and data disclosure from the industry**. In fact, the projects' results shed light on the need of future research on several aspects, including: the role of a coordination entity for "multiple" collective systems as an alternative to "single" EPR system, the evaluation of policies aimed at expanding the adoption of eco-modulation of ERP fees, the economic efficiency of parallel packaging collections systems such as deposit schemes.

Executive Summary with a focus on the Italian System

The project "**Screening the efficiency of packaging waste in Europe**" has been promoted by Consorzio Nazionale Imballaggi (CONAI) with the support of the Extended Producer Responsibility Alliance (EXPRA). The project assesses the performance of different packaging waste Extended Producer Responsibility (EPR) systems across Europe, with a focus on the activities conducted by the Producer Responsibility Organizations (PROs). An econometric analysis and an indicator-based assessment are adopted to provide a quantitative analysis of the **cost efficiency** and **effectiveness** of **25 Member States'** EPR systems and **21 PROs, including CONAI**. Furthermore, though an ad-hoc survey collecting data from more than 20 European PROs, the project evaluates the coherence of **PROs' tariff schemes** in relation with the environmental goals of waste packaging management.

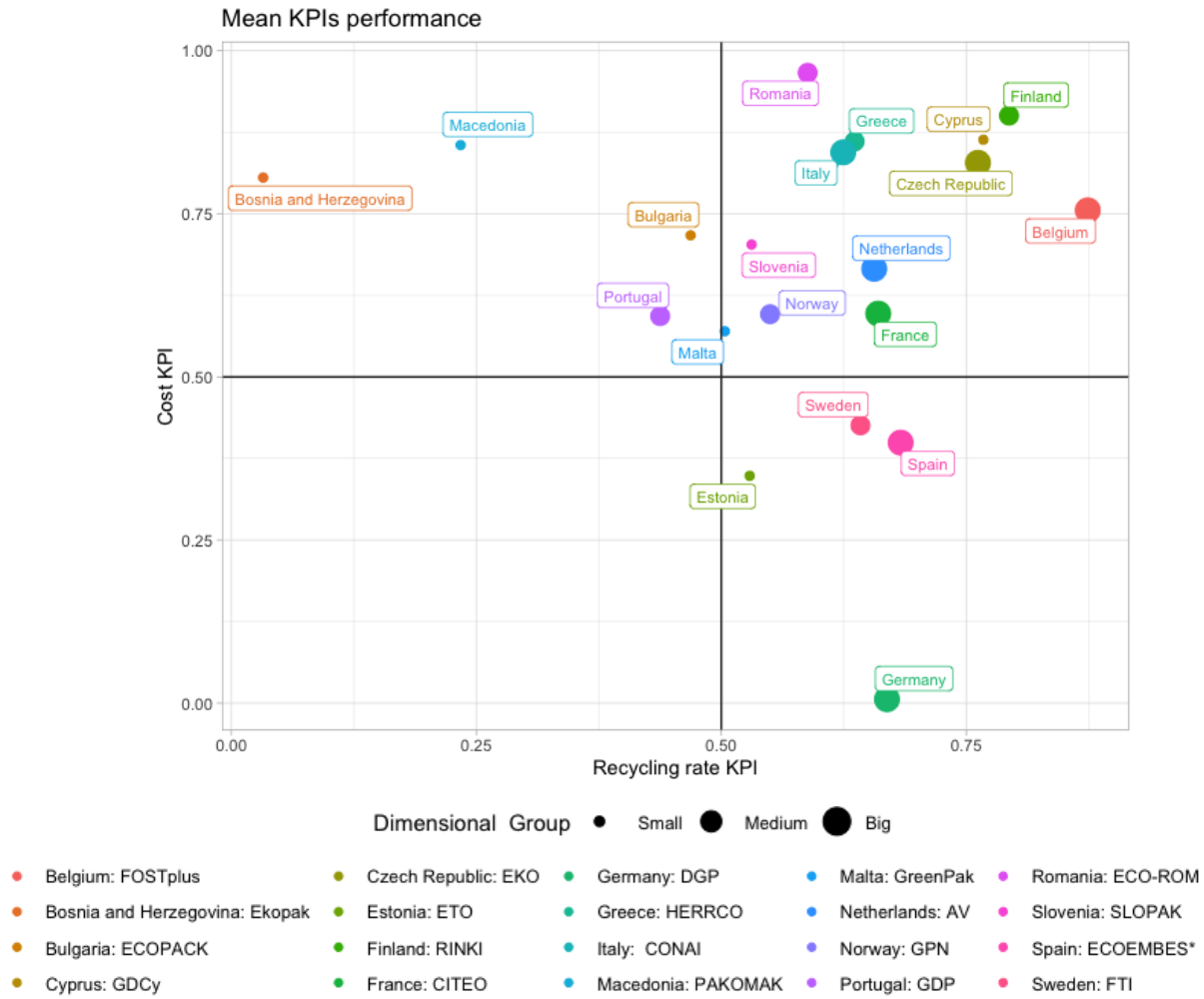


Figure 1: The Figure shows the mean of the normalized score in the KPIs, collected from 2014 to 2019. The following packaging materials are included for the computation of the overall score: plastic, paper, wood, metal, glass. Data for Spain includes the performance of ECOEMBES and ECOVIDRIO, while for Belgium includes FORST-Plus and Valipac (the KPIs disaggregated by these PROs is presented in the Annex II, Table S2). Data for DGP is limited to the years 2017-2019. The full list of PROs' acronyms is reported in the Annex I.

The primary result of the research is that PROs' **recycling effectiveness is not necessarily associated with high EPR systems' costs**. Through the indicator-based assessment we identify a group of PROs that is both more effective in recycling and cost-efficient than the European average (Figure 1). **CONAI achieves a higher-than-average performance both in the cost-efficiency and in the recycling effectiveness KPIs**.

When compared to the PROs sharing a similar market dimension (large and populous countries) CONAI registers a top performance as for the cost-efficiency and an average performance as for the recycling effectiveness (Figure 2). The Italian collective system is **among the best in the management of paper and glass packaging**, while it is relatively **less well positioned as for plastics' recycling effectiveness**. Nevertheless, CONAI's effectiveness in **plastics' recycling has improved in recent years**.

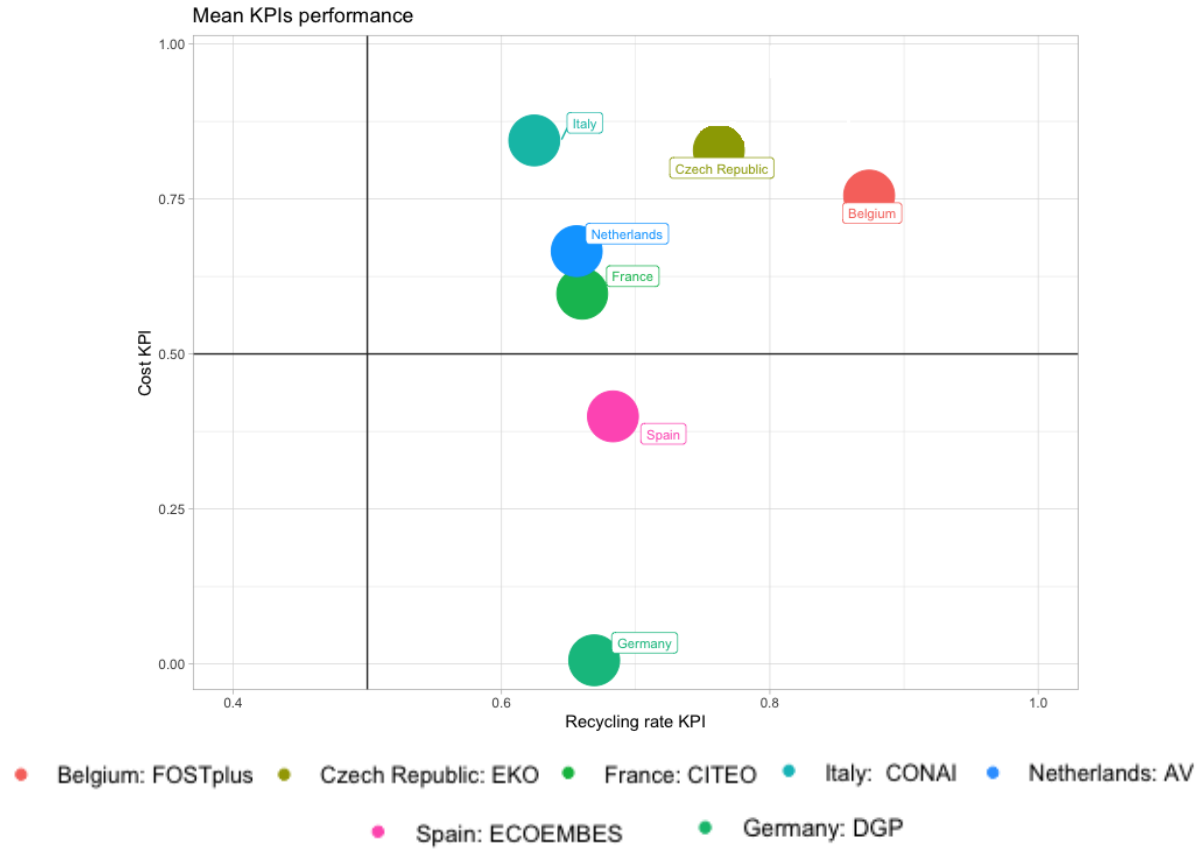


Figure 2: The Figure shows the mean of the normalized score in the KPIs, collected from 2014 to 2019, across all PROs operating in a "big" market (more than 10 million inhabitants served). The following packaging materials are included for the computation of the overall score: plastic, paper, wood, metal, glass. Data for Spain includes the performance of ECOEMBES and ECOVIDRIO (the KPIs disaggregated by these PROs is presented in the Annex II, Table S2). Data for DGP is limited to the years 2017-2019.

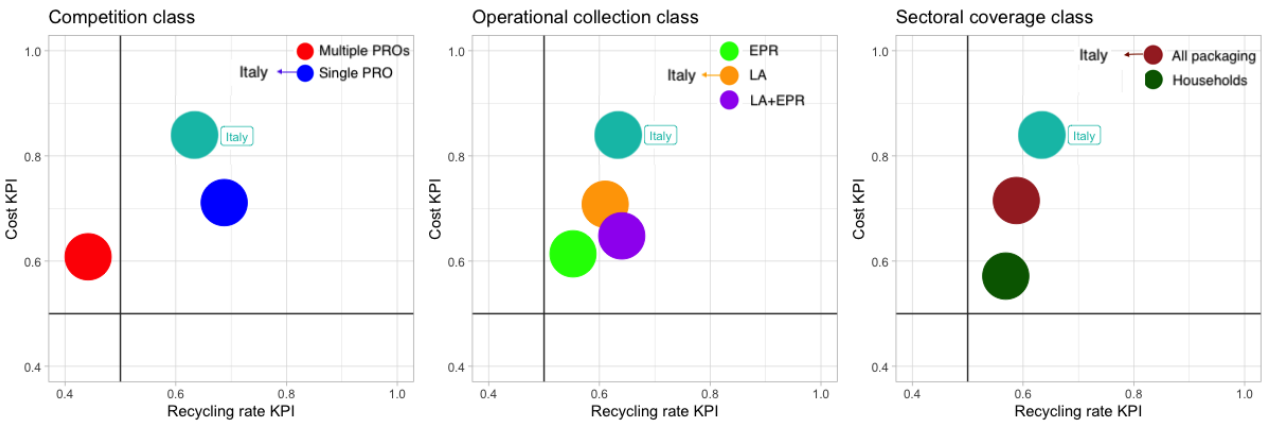


Figure 3: The Figure shows the mean of the normalized score in the KPIs, collected from 2014 to 2019, across PROs' categories. The following packaging materials are included for the computation of the overall score: plastic, paper, wood, metal, glass.

The analysis based on the KPIs sheds light on the heterogeneous performance of PROs across different groups: "single" PROs have a higher average score in both the cost and recycling KPIs than "multiple" PROs. Systems in which the operational responsibility for the collection of households packaging falls on the Local Authorities (L.A.) are one average more cost-effective than systems directly relying on PROs. Furthermore, EPR systems managing only the households' waste have on average higher unitary costs than systems that include also the commercial and industrial packaging. CONAI's performance is in all cases either equal or above the performance of its class.

Though the econometric analysis we assess the impact on the recycling rate of the EPR schemes' characteristics, of the National waste management system and of macroeconomic conditions. We find that PROs that operate with a shared responsibility through a unique, non-competitive system **achieve,** on average and *ceteris paribus*, a **recycling rate of total packaging 8 percentage points higher** than systems that operate in competitive environments with multiple PROs. **Financial resources are used more efficiently in the former group**, although results vary greatly by material and a particularly low performance across all EPR categories is found as for plastic packaging when EPR costs are below the European average. When local authorities are involved in the operational responsibility of collection, higher recycling rates are expected, on average and *ceteris paribus*. Our empirical findings suggest that the increase in the ERP cost per capita, often driven by the introduction of fees' eco-modulation, significantly affects plastics' recycling rate.

The analysis based on the survey's responses finds that **EPR fees' modulations is mostly based on qualitative and operational criteria**, rather than on the recyclability of materials or the share of recycled materials used in packaging production (the latter are adopted in 20%-30% of the cases).

This result shows that there is still **a large untapped potential for PROs to foster a more circular path** for the packaging waste production. CONAI, thanks to the introduction of a broad eco-modulation of plastics' fees based on materials' recyclability, performs better than the groups' average. Further improvements for the Italian system include an additional modulation of the packaging fees based on the share of bio-based or recycled materials used in the production. Best practices as for the eco-modulation are Citeo (France), Grüner Punkt (Germany) and Ecovidrio (Spain).

Our empirical findings support the hypothesis that unique, non-competitive system can benefit from a range of different aspects that may include: optimization of logistics and processing costs from an homogeneous territorial distribution, reduction in administrative burdens, more effective communication between actors, avoidance of opportunistic behavior. At the same time, it is important to underscore that the restrictions and entry barriers characterizing non-competitive systems must be carefully assessed when the system is launched, and that monitoring should be effectively implemented.

Although several PROs shared their data openly and with engagement, data disclosure on operational results and costs is generally lacking across Europe. CONAI, together with Citeo (France), is among the PROs providing the greatest detail of information from publicly available reports. New economic assessments of EPR systems across Europe and in Italy will greatly benefit from an **improvement of transparency and data disclosure from the whole industry**. In fact, the projects' results shed light on the need of future research on several aspects, including: the role of a coordination entity for "multiple" collective systems as an alternative to "single" EPR system, the evaluation of policies aimed at expanding the adoption of eco-modulation of ERP fees, the economic efficiency of parallel packaging collections systems such as deposit schemes.

Introduction

The Extended Producer Responsibility (EPR) is "*an environmental policy approach in which producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle*" (OECD, 2001). In the European Union, packaging waste is one type among the different streams of waste that EPR systems manage, in accordance with the Packaging and Packaging Waste Directive (94/62/EC) [1]. EPR shifts away from traditional solid waste management approach, by re-allocating administrative, financial and physical responsibility to the polluter (in compliance with the polluter-pays principle - PPP[2]). In the EPR schemes the polluter does not coincide with the individual consumer, but rather it refers to the economic agent (the producer). The producer is appointed to avoid pollution through the recycling of waste and the reduction in the generation of the materials that will be transformed into waste after the product's use. Currently, European waste legislation provides broad guidelines for the application of EPR framework in Europe. Although the ultimate goals of recovery and recycling targets described in the Packaging and Packaging Waste Directive 94/62/EC and amended by the Circular Economy Package (EC, 2018) are common to all Member States, the strategies for achieving these targets vary considerably (Crutz et al., 2014). The recent revision of the Directive 94/62/EC included in the "Circular Economy Package" a set of new common EU targets for packaging waste recycling, that by 2030 should reach 70% of waste generation, with specific new targets set for all packaging waste materials (paper, wood, glass, plastic, aluminium and steel). Despite being based on an individual obligation, the compliance of the EPR principle in Europe is fulfilled collectively by the operations of the Producer Responsibility Organisations (PROs). PROs are collective entities established by producers and regulated through Member States' legislation, which become responsible for meeting the recovery and recycling obligations of the individual producers on their behalf. PROs carry out the following functions: i) financing the collection and treatment of the product at the end of its life; ii) organising and supervising the collection and treatment activities; ii) managing the monitoring and data acquisition of collection and treatment operations. PROs fund their systems through an environmental levy that is paid by packaging producers and users on the base on the units sold on the market (henceforth the "EPR fee"). The operational and financial responsibility of PROs varies across Member States and,

[1] An overview of all existing EPR schemes in the EU-28 in 2013 is given in Development of Guidance on Extended Producer Responsibility (EPR), 2014; the products covered are defined by ELV Directive 2000/53/EC, the new WEEE Directive 2012/19/EU and the Batteries Directive 2006/66/EC, in addition to: used oils, used tyres, graphic paper and textile, medicines, fluorinated refrigerant fluids, agricultural films, mobile homes, furniture, etc.

[2] Under the 1972 and 1974 OECD Recommendations, the Polluter-Pays Principle means that the polluter should bear the "costs of pollution prevention and control measures", the latter being "measures decided by public authorities to ensure that the environment is in an acceptable state" (OECD, 1972).

within a country, across sectors. In fact, as the EPR principles established in the EU legislation are flexible, Member States have adopted various implementation approaches, which have led to a high degree of heterogeneity in the packaging waste markets (for a review, see Filho et al., 2019).

Only a relatively narrow group of studies has analysed the role of EPR systems in the packaging waste sector. Gupt and Sahay (2015) carried out a comparative analysis of 27 cases from developed and developing economies (including a set of European EPR schemes), exploring how the presence of EPR-based regulations and their characteristics (financial responsibility, role of stakeholders) affected the achievement of recovery and recycling targets. Using an exploratory factor analysis, Gupt and Sahay (2015) find that the factors that contribute significantly to the success of the EPR-based environmental policies are a clearly defined financial responsibility of the producers and the presence of separate collecting and recycling agencies. Regulatory provisions, take-back responsibility and financial flow come out to be the three most important aspects of the extended producer responsibility. Cahill et al. (2010) conduct a case-study analysis of 11 European EPR systems based on the following characteristics: legal basis for transposition and EPR systems, national targets, financing mechanisms and share of responsibilities between producers and local authorities. The authors find that where local authorities have been engaged in the design and implementation of national systems, existing waste infrastructure used and defined roles established for producers and local authorities, results have been significantly more positive than in the cases where local authorities have had limited engagement. When PROs are directly studied, often few of them are involved in the analysis. Rubio, et al. (2019) for instance carried on a case study based on interviews, describing whether EPR policies in Portugal have achieved their environmental targets. Rubio et al., (2019) find that there is no evidence that a centralised organization is preferable to the introduction of competition among PROs or vice-versa. The latter is an open and debated issue in the literature evaluating the role of different EPR implementation: the support to monopolistic market structures comes from the assumption that economies of scale can be exploited fully. This motivation can be of particular importance for small countries in which waste packaging volumes might not be sufficient to allow competition in practice (Rubio et al., 2019). On the other hand, the advantage of the Multiple schemes can be their potential of reducing costs. Kuntz et al. (2014) for instance analyse the reduction of waste management costs in Germany, finding that the increase in the competition between PROs has been associated with improvements in recycling services. The analysis conducted by EC (2014) is one of the most comprehensive comparative reviews of PROs performance. It includes a benchmark analysis consisting in a systematical comparison of technical (for example recycling rate over quantity put on the market) and financial performances (for

example fees collected per inhabitant or per tons). A recent investigation by the OECD concludes that there is insufficient empirical evidence to determine the conditions in which a monopoly PRO is more efficient than competing PROs (OECD, 2016).

Another strain of the literature has evaluated the costs of packaging waste systems across Europe (in Portugal by Cruz et al., 2012; in France by Cabral et al., 2013; in Belgium by Marques et al., 2014; in France, Portugal and Romania by Cruz et al, 2014; in Portugal, in France, Belgium and Italy by Rigamonti et al., 2015; in Denmark by Larsen et al., 2010), finding that EPR systems cover a part of the packaging waste costs. These studies typically assess the role of EPR systems based on case studies analysis which provide useful insights of the functioning of the specific systems but fail to provide a generalized quantification of the impact that different EPR schemes have on the success of the packaging waste collection and recycling. A different set of studies has studied the determinants of collection and recycling rates using macro-level (Mazzanti et al., 2009a; Johnstone, and Labonne, 2004; Sverko et al. 2020) and micro-level (Mazzanti et al., 2009b) panel data, using as key explanatory variables a set of macroeconomic and socioeconomic conditions. These analyses generally find that recycling rates have increased in the EU along with economic development, and that higher degrees of urbanization lower recycling rates. The econometric panel-based approaches provide an interesting direct quantification of the role of many economic variables but, on the other hand, typically lack to control for differences in the EPR systems characteristics, due to lack of a homogeneous framework of classification.

This study aims to cover an important gap in the literature as it evaluates the performance of packaging waste management schemes across Europe within a quantitative framework. We conduct an assessment of both national EPR systems and specific PROs' activities, by adopting a suite of different methods and a novel dataset of financial, operational and institutional data. In particular, the analysis aims to identify the role that different EPR schemes and PROs' activities can have on the operational and economic performance of the systems, identifying the factors that can improve the cost efficiency and effectiveness of packaging waste management.

Data

We assemble a large panel dataset (across Member States and over time) covering many different aspects of packaging waste management: i) the level of the EPR fees across PROs, materials and sectors; the ii) the operational results of packaging waste management both at the national level and

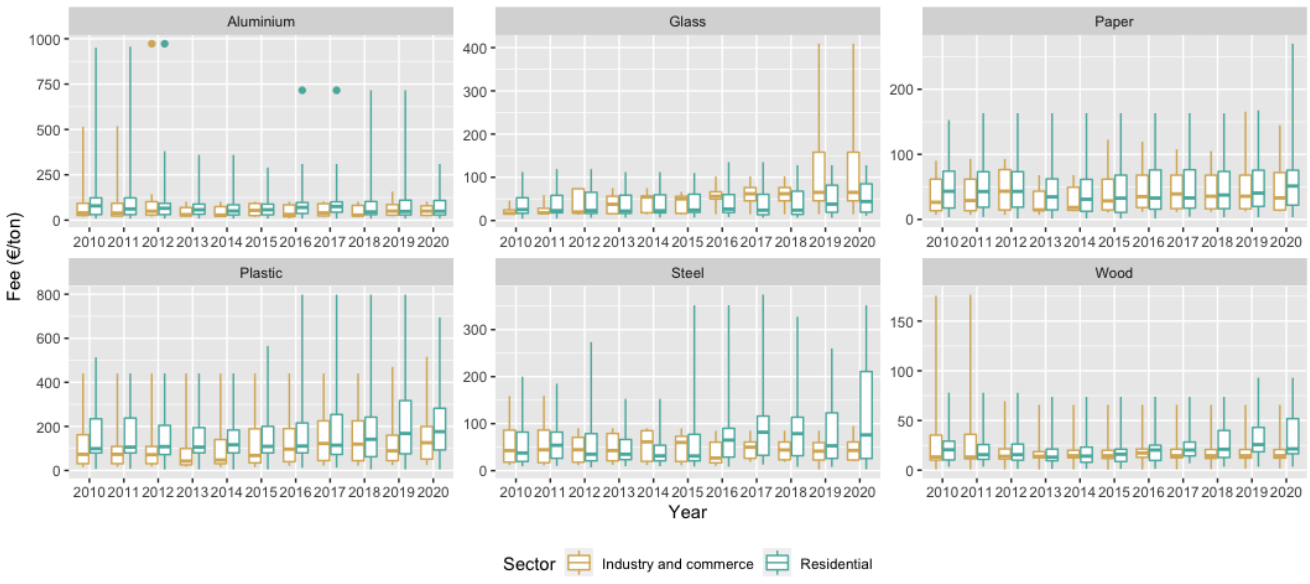
by PRO; iii) a classification of the institutional and governance setting of the EPR systems; iv) a set of socio-economic and macroeconomic variables related to the waste management sector.

The lack in the availability of detailed data on PRO's operational and economic information has long been recognized a key bottleneck preventing a detailed and quantitative study of such systems (EC, 2014). Poor data availability and data confidentiality in fact is common as several PROs are in competition (EC, 2014). Furthermore, methods for data collection and reporting differ from one country to another, leading sometimes to uncertainty in data comparison. Within this study we have been considerably expanding the set of data analysed with respect to previous studies (see for instance EC, 2014), although the data collection strategies adopted have been only partially able to overcome the lack of data. Macroeconomic variables used in the analysis derive from EUROSTAT database[3]. The following paragraphs describe in detail the sources and coverage of the variable included in this study and related to the EPR schemes and the PROs' activity.

EPR fees

The data on the level of the EPR fees applied year-by-year by each PRO has been gathered from the reports provided by EXPRA (available from 2017 to 2020) and PRO-Europe (available from 2010 to 2019). From these sources it was possible to create a dataset for the period 2010-2020 for 35 different PROs, containing fees for each material (aluminium, biodegradable, composite, glass, paper, plastic, steel, wood), and even sub-materials, distinguished between household and commercial/industrial packaging, if applicable.

Figure 1 - Evolution of fees over time by material and sector



[3] EUROSTAT (March, 2021). https://ec.europa.eu/eurostat/data/database

EPR system characteristics

The data on the operational characteristics of EPR system, including the classification on PROs' financial and operational responsibility, the number of inhabitants covered, the amount of packaging waste placed on the market, recovered and recycled by material and the type of collection strategy adopted in the country, are gathered from the documents of the reporting activity of EXPRA (available from 2014 to 2019). As the latter source provides information only on the PROs associated to EXPRA, data for PROs which are associated to PRO-Europe or which are independent from any pan-European organization have been gathered by inspecting the operational reports of each PRO, when available (such as Ponto Verde, 2019; CITEO, 2019) and by National institutional sources (such as the packaging Portal of the German Federal Ministry of the Environment). The quantitative and qualitative information collected have been used in our analysis to summarize PROs' performance and heterogeneity.

Financial data

The financial information of PROs has been collected by inspecting the balance sheets of each company over time, available from the ORBIS Bureau van Dijk database[4]. PROs Balance Sheet and Profit & Loss Statements are available on the database for the period from 2010 to 2019, but with different extents depending on the PRO: first, we were able to identify only 24 PROs which have published their statements; secondly, the availability of data reported varies across each of these PROs, depending on the year and the budget items considered. The most relevant budget items (PROs' costs and revenues) from the ORBIS database cannot be split into more specific components. Therefore, the lack of further detailed budget items based on operational phases restricted the possibility to include such variables in the econometric framework of the analysis. Furthermore, a given budgetary item in the statements is not always perfectly comparable across PROs, as for instance revenues from fees' collection and costs associated with collection activities are recorded under different budget items, depending on the PROs. Therefore, a more detailed analysis of the financial performance of PROs falls out of the scope of our work due to the lack of detailed data on PROs' costs and revenues by type of operation and packaging waste material.

Classification of EPR systems' characteristics

We classify the system in which PROs operate though an analysis of the literature and in particular based on the classification proposed by EXPRA's annual reports. We identify different aspects:

[4] ORBIS - Bureau van Dijk. (February, 2021). https://orbis.bvdinfo.com/

market structure, operational responsibility for collection and recycling, financial mechanism, market dimension.

- **Market structure:** if there is only one PRO operating as an EPR compliance scheme in a given market segment, we consider it to be a monopolistic PRO ("Single" category). In on the other hand contrarily a PROs operates in competition ("Multiple" category). When more than one PRO exists in a packaging system, they can indeed have different scopes (households and/or commercial/industrial), as in the case of the Belgian and Austrian systems[5] or they can serve different material streams of packaging waste, as in the case of Spain where Ecovidrio covers the stream of glass and Ecoembes is responsible for the flows of paper and cardboard in addition to plastic and metal. These cases are not to be considered competition in our classification. National systems with one or more than one monopolistic PRO fall within the category "no-competition", while on the other hand the other fall in the category "competition". Systems in the households packaging waste collection are classifies within a different group than PROs operating in the industry and commerce sectors. Henceforth, we focus on the classification of the households packaging waste collection sector when we refer to "Single" or "Multiple". We mapped the presence of deposit schemes, but we assume that "monopolistic" PROs can co-exist next to a deposit scheme (i.e. they do not compete on a given material).
- **Operational responsibility for collection and recycling for household**: PROs can alternatively rely on local Authorities (class name "L.A."); private contractors (class name "EPR"); a combination of the two ("L.A. and EPR"). Unfortunately, lack of data constrained the classification: it was not possible to find widespread information (i.e. over the period from 2010 to 2020, for a minimum sample of 20 PROs) on the differences across materials, on regional and national differences in the implementation of selected solutions and on different types of contracts with independent private operators.
- **Financial mechanism:** Depending on the rules adopted in the Member State, PROs set the value of their fees in accordance to the total costs of packaging waste ("no cost-sharing mechanism") or to a quota of such costs ("cost-sharing mechanism"). In the latter case the quota is based on a quantification of the additional expenses related to the separate collection of packaging ("cost-sharing mechanisms"). The definitions of perimeter of what is considered within or outside the system costs can vary depending on the EPR system. The lack of data across Member States on the specific rules and criteria adopted in the identification of the cost-sharing mechanisms

[5] Rubio, S., et al. 2019. Effectiveness of extended producer responsibility policies implementation: The case of Portuguese and Spanish packaging waste systems, *Journal of Cleaner Production*, Vol. 210, 217-230. https://doi.org/10.1016/j.jclepro.2018.10.299

resulted in a partial coverage of this metric. Due to the lack of information, we model this characteristic by the inclusion of a dummy variable when the system is based on any "cost-sharing mechanisms". For this reason, a more in-depth analysis of the implications on EPR systems' performance of different cost-sharing mechanisms is left for future research. This aspect underscores the importance of reporting by Member States and EPR system on the rules defining the cost-sharing mechanisms. We also map the presence of parallel financial mechanisms (deposit fees, taxes on packaging) or alternative ones (allowances' markets).

- **Marker dimension:** PROs (as well as national EPR systems) have been classified based on the number of inhabitants served (i.e. with access to infrastructure): "Small" PROs serve less than 3,5 million inhabitants; "Medium" PROs serve between 3,5 million inhabitants and 10 million inhabitants; "Big" PROs serve more than 10 million inhabitants.

Figure 2 depicts how the sample of selected PROs can be divided into 13 different groups, based on the characteristics of the market (Competition – No-competition), their dimension (Small – Medium - big) and the operational responsibility of households packaging collection (Local authorities - Local authorities & EPR - EPR). A detailed grouping of the sample of PROs is given in the Annex. The two distinct competition categories are equally observed in the analysed sample.

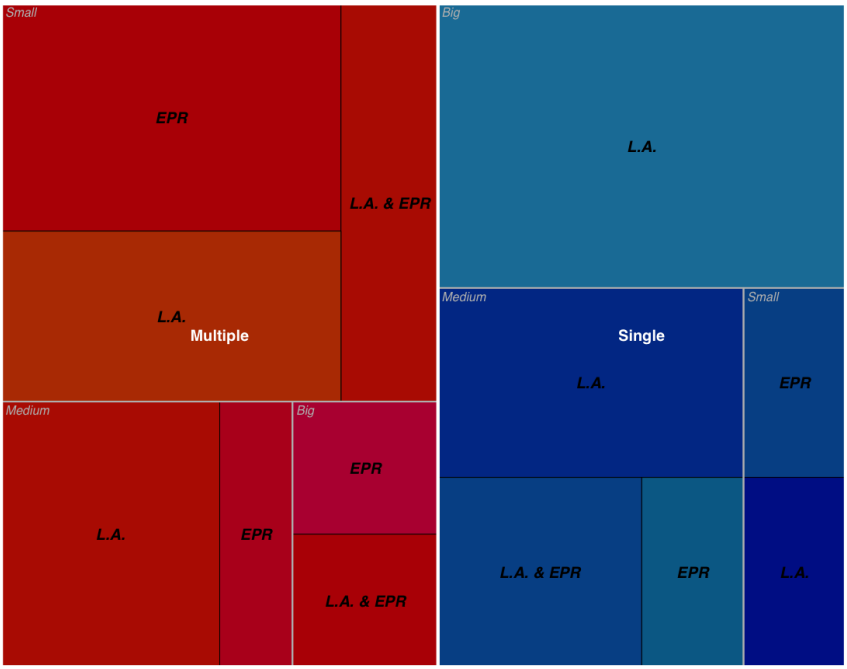


Figure 2 – Classification of PROs

Methods

Regression model

We adopt a pooled regression model based on a panel dataset in which observations are collected for each country (i) and year (t). The dependent variable of the model is the total and material-specific recycling rate (y_{it}). A specific model is estimated for all packaging, Paper, Glass, Plastic and Metals[6]. The independent variables are grouped into three categories, related to: i) EPR schemes' characteristics (EPR), ii) national waste management characteristics (Waste), iii) macroeconomic environment (Macro). In particular, our key specification investigates the role of EPR system costs over the recycling performance of the country, taking all other aspects of the EPR and waste management system into account. Our first specification is therefore the following (eq. 1):

$$y_{it} = \alpha + \beta cost_{i,t} + \gamma EPR_{i,t} + \delta Waste_{i,t} + \theta Macro_{i,t} + \varepsilon$$

With i: 26 countries, t: years from 2010 to 2019.

In a second step, we test if specific characteristics of the EPR system affect the influence that EPR system costs have on the recycling performance of the country, by interacting the vector of variables $EPR_{i,t}$ with the variable $cost_{i,t}$, leading to the following specification (eq. 2):

$$y_{it} = \alpha + \beta_1 cost_{i,t} + \gamma EPR_{i,t} + \beta_2 (cost_{i,t} * EPR_{i,t}) + \delta Waste_{i,t} + \theta Macro_{i,t} + \varepsilon$$

Table 1 reports the main statistical information of the dependent variables included in the study.
We estimate the multivariate regression model by Ordinary least Squares (OLS). We control for the presence of possible multicollinearity among the different EPR system categorical variables as well as among the macro-economic variables by calculating the variation inflation factors (VIF) of all predictors in regression models[7]. Alternative models characterized by the inclusion of a different set

[6] The differences in the reporting of metals packaging (in most cases it is not possible to distinguish between steel and aluminium packaging) across Member States resulted in a much more limited panel than the panel collected for the other materials (around 50 observations for metals, while 200 observations for the other materials). We do not show the results for metal packaging due to the poor statistical power of the econometric model deriving from such a low number of observations.

[7] The VIF of a predictor is a measure for how easily it is predicted from a linear regression using the other predictors. Taking the square root of the VIF tells you how much larger the standard error of the estimated coefficient is respect to the case when that predictor is independent of the other predictors. A general guideline is that a VIF larger than 5 or 10

of independent variables have been compared by inspecting the predictive power of the model, and the model with the highest R squared and Akaike Information Criterion[8] (AIC) have been selected for the analysis of the results.

Table 1 - Variables included in the econometric analysis

Variable	Variable type	Unit	Value		
EPR competition	Categorical		Single; Multiple		
Responsibility for collection	Categorical		EPR; Local authorities; Local authorities and EPR.		
Responsibility for recycling	Categorical		EPR; Local authorities; Local authorities and EPR.		
EPR financing for collection	Categorical		Full; Shared; Permits; Tax		
Type of collection strategy	Categorical		Door-to-door; Bring points; Mixed		
Deposit	Categorical		Yes; No		
Co-mingled collection	Categorical		Yes; No		
Scope			Households only/All packaging		
			Min	**Mean**	**Max**
Recycling rate	Continuous	%	28	63	85
EPR cost	Continuous	€ per capita	0.3	9	56
Share of waste exports extra EU over total MSW	Continuous	%	4	10	23
Price of waste materials	Continuous	€/ton	126	140	160
Public expenditure on waste	Continuous	€/ton	48	141	404
Municipal waste generation	Continuous	Kton	245	7.150	50.260
Population density	Continuous	Persons / sq. km	16	169	1495
GDP per capita	Continuous	Thousand € per capita	20	44	98

Partial metrics

Although this research adopts as primary empirical method the regression model described in the previous section, we enrich the analysis by the use of partial metrics. The latter can investigate if results obtained through the econometric analysis can be supported by the analysis of data referring to the operations of each PRO.

The classification of the EPR systems has been adopted also in the analysis of the "Single" PROs. First, in order to investigate the overall level of PROs' efficiency through a quantitative benchmark,

is large, indicating that the model has problems estimating the coefficient. In all cases, the VIF of the dependent variables included does not exceed the threshold of 5.

[8] TheAIC is an estimator of prediction error and thereby relative quality of statistical models for a given set of data. It takes into account the trade-off between the goodness of fit of the model (R squared) and the simplicity of the model (number of independent variables in the model).

we identified two KPIs. The first KPI selected is the **normalized recycling rate** (henceforth "recycling KPI"), defined as:

$$norm(\frac{Recycled_{m,t}}{PoM_{m,t}})$$

The second KPI is the **normalized cost per ton of recycled material** (henceforth "cost KPI"), defined as:

$$norm[\frac{(Fee_{m,t} * PoM_{m,t})}{Recycled_{m,t}}]$$

With

- *m*, material type
- *t*, year
- *Fee,* mean fee asked by PROs
- *PoM*, placed on market (ton)
- *Recycled*, tons recycled
- *Norm:* data have been normalized through min-max normalization, one method of rescaling the range of figures to allow each one contributing approximately proportionately to the final range. Both KPIs range from 0, indicating the worst performing PROs, to 1 toward which the best performers are positioned.

The cost KPI should differs from the EPR fee as the former depends on the level of the fee as well as on the recycling rate. We compute the KPIs for all materials and for each material type.

We associate the analysis of the operational KPIs with an analysis of the financial ratios of the PROs. A ratio analysis is a quantitative method that allows to gain insight into the liquidity, profitability, solvency and productivity of a company by studying their financial statements. As most of the PROs analyzed operate following a not-for-profit purpose, the set of indicators selected has been adapted on sector specific characteristics. Despite not-for-profit organizations cannot be studied only by measuring profit maximization or economic and financial performance, the literature has adopted financial indicators also when studying such activities (Costa et al., 2012, Bartolacci et al., 2018)[9]. Notwithstanding the due specificities, it is in fact important to include in the analysis of non-for-profit companies, indicators that monitor the operating income and other financial parameters, in order to understand whether in the short-term, PROs' revenues can be covered by the current operating costs and in long-term if a no-profit organization is able to cover its debt. In fact, even for non-for-profit companies a disequilibrium in financial flows would negatively influence the results of EPR implementation, potentially resulting in less efficient services and/or higher fees.

[9] Costa et al., 2012 include: profit/turnover; turnover/total operating expenses; equity/total assets; fixed assets/total assets. Bartolacci, F., et al. (2018) relate one financial indicator, ROA, with a set of quantitative and qualitative information to understand whether and how choices oriented toward environmental protection and contextual factors influence waste management companies' revenues and costs, which, in turn, affect their financial sustainability and ongoing viability.

It is important to underscore that partial metric methods alone fail to account for the relationships among different factors: KPIs and specific indexes alone cannot explain EPR systems and PROs' overall performance in terms of cost efficiency and effectiveness. The evidence gathered through the KPIs and the indicators is nonetheless an important source of insights complementing the results based on the econometric model.

Results

Analysis of EPR schemes' performance

The pooled regression models for all packaging and by material identify a range of statistically significant variables. First of all, we find that the preferred specification of each material points to the lack of predictive power of macro-economic indicators, namely the GDP per capita. This result is in contrast with part of the literature evaluating the determinants of the waste management performance and can be attributed by the rich characterization of the econometric model as for the variables mapping the EPR system, as well as the detailed information regarding the collection schemes (material specific types of collection and presence of deposit schemes). The latter group of variables is on the other hand statistically significant, although some differences in the magnitude and the sign are found across different materials. The regression output for different specifications of the model is presented in the Tables S2 – S5 in the Annex. As our model is specified as a linear equation, the coefficients quantify the incremental contribution on the recycling rate of a given variable (i.e. the additional percentage points from the mean recycling rate), all other things equal.

Our first model specification (models 1, 2 and 3 in Tables S2 – S5, corresponding to the equation 1) disentangles the effect on the recycling rate of different key EPR system characteristics. First, we find that "Single" EPR systems increase the recycling rate with respect to "Multiple" EPR systems with competing PROs (see Figure 3). We consider such measure as a proxy of **effectiveness**, because the coefficients measure the degree to which this characteristic of the EPR system is successful in producing the desired result (a higher recycling rate), no matter the cost.

Our preferred model specification (models 4 and 5 in Tables S2 – S5, corresponding to the equation 2) allows to disentangle the contribution of different levels of EPR system costs on the recycling rate across different competition classes (see Figure 4). The coefficients deriving from the interaction of the two variables allow to identify a proxy of **efficiency**, as they measure the ability to accomplish the desired result (higher recycling rate) with the least amount of money. We find that financial resources are used more efficiently in "Single" systems as, holding the EPR costs constant,

this category is always characterized by higher recycling rates. Only at very high costs the difference in the performance of the two groups becomes statistically not significant. Increasing the cost improves the recycling rate non-linearly and at a different marginal rate depending on EPR Group. In Single systems characterized by high costs, a saturation effect reduces the marginal variation in the recycling rate due to a marginal increase in the cost. Similar, statistically significant, effects emerge from the material-specific analysis. Single EPR system are associated with higher recycling rates of paper for any given level of the EPR costs. The effect of different EPR groups as for the costs of plastic packaging is instead similar at low-cost levels, while only Single systems manage to achieve higher plastic recycling rates when EPR system costs above the mean values observed (8 € per capita). Multiple systems are characterized by higher recycling rates of glass packaging when EPR costs are low (0.2-0.5 € per capita), while Single systems are associated with higher rates at costs above 0.5 € per capita.

Figure 3 - Predicted recycling rate by EPR system class

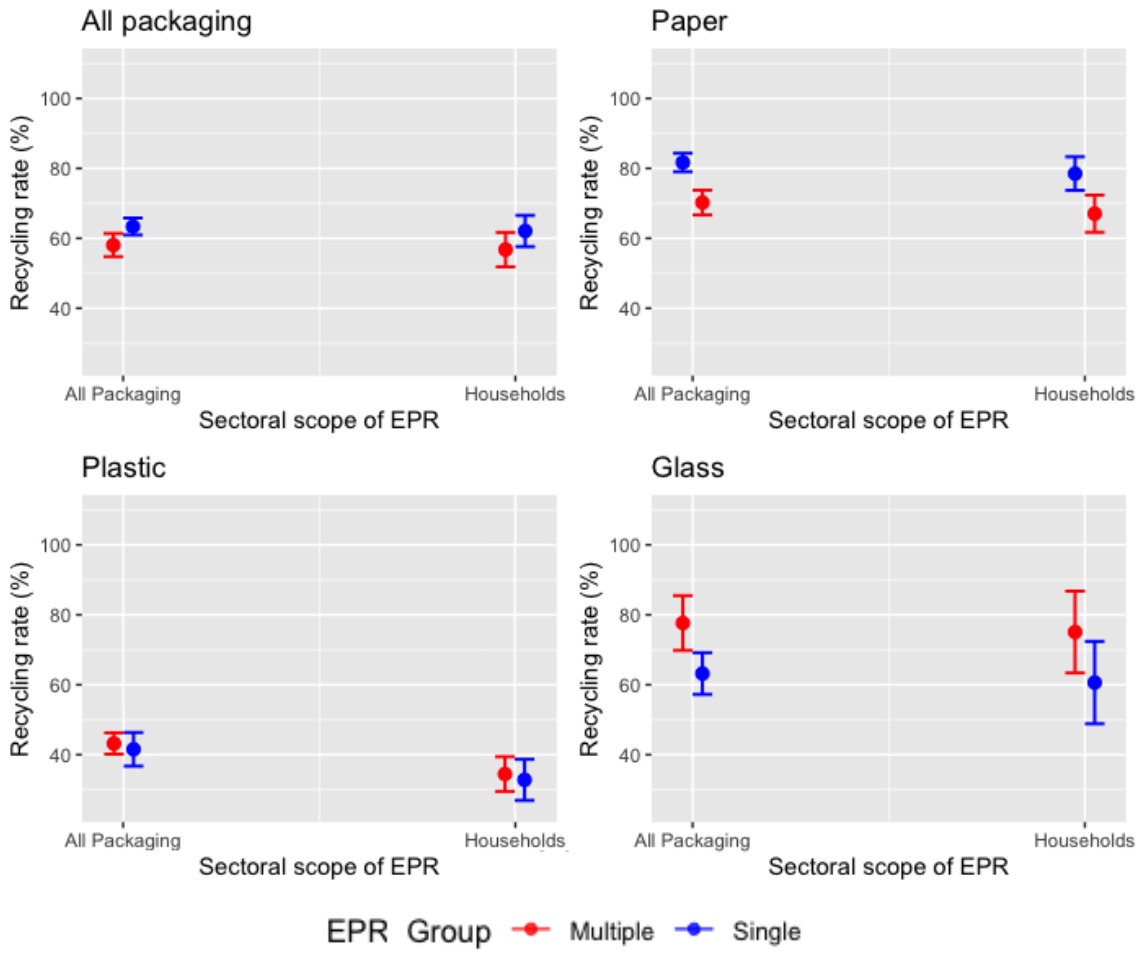
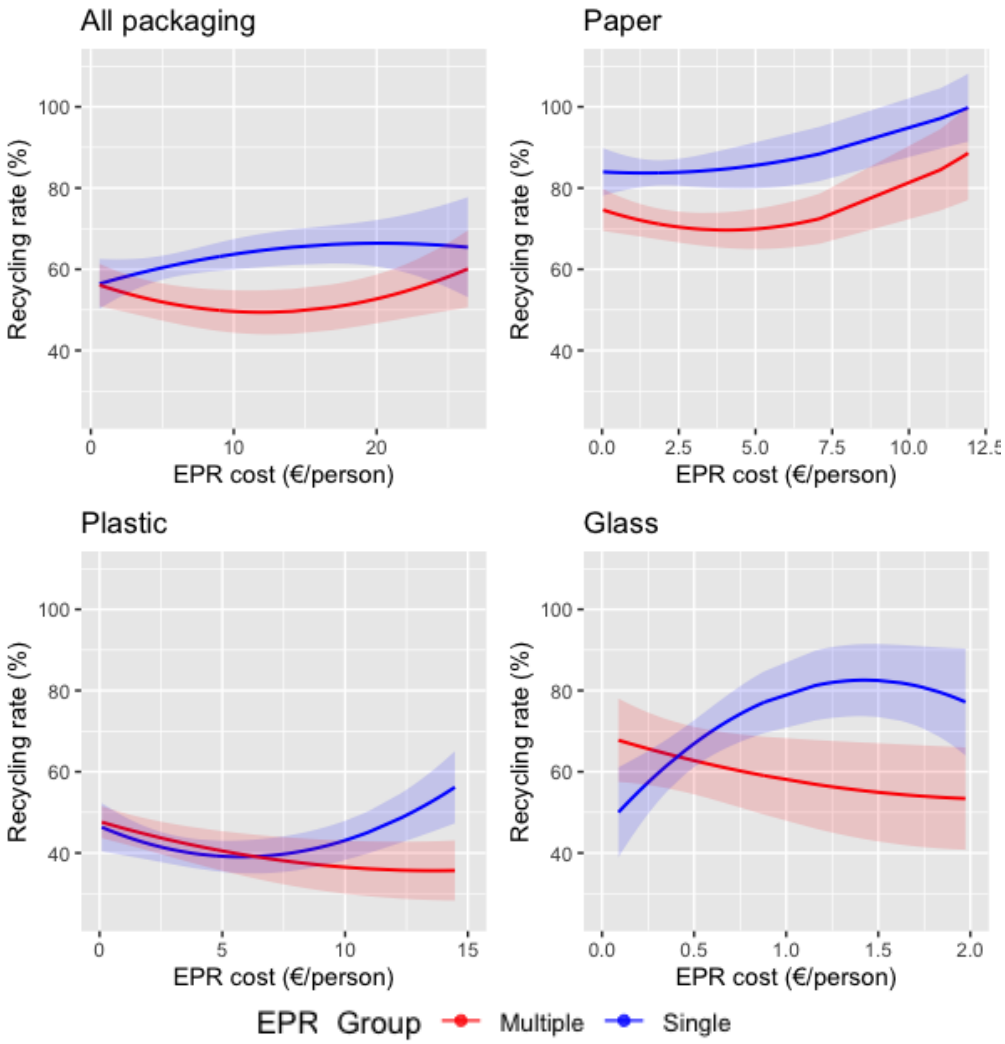


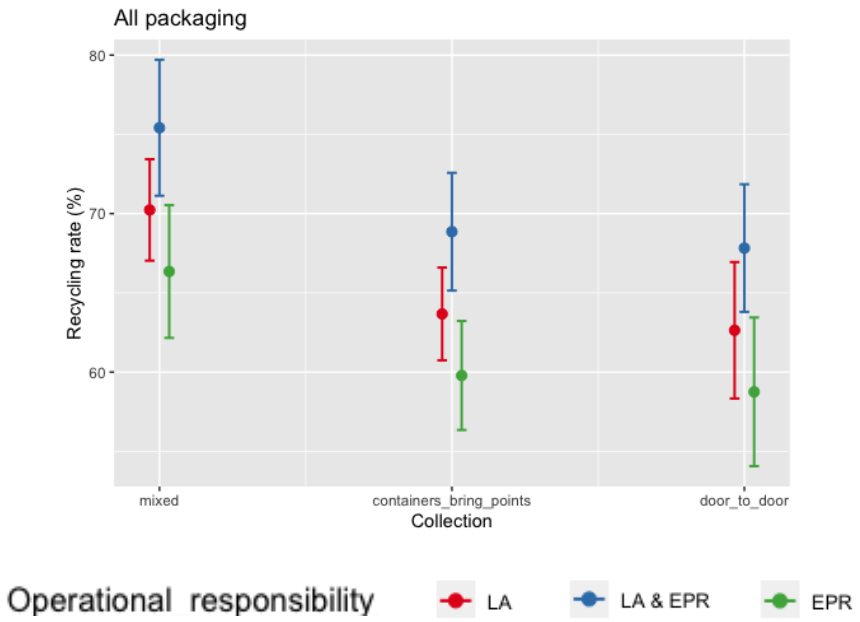
Figure 4 - Predicted recycling rate by levels of EPR costs and EPR system class



The collection strategies and the operational responsibility of collection are other key explanatory variables with statistically significant effect across model specifications (Figure 5 shows the results for all packaging, while the figures S1 and S2 in the Annex show the results for each material). Across all packaging materials, higher recycling rates are expected when the operational responsibility of collection falls on local authorities or on both local authorities and EPR systems. Furthermore, mixed collection strategies, comprising both door-to-door and bring point options, are associated with higher recycling rates than in the cases in which the collection relies only on containers or door-to-door collection. Results vary depending on the material, as we find that door-to-door collection with respect to the other alternatives increases the plastic recycling rate by 4 percentage points, while the mixed collection is particularly effective for paper packaging, as it increases the recycling rate by 10 percentage points. Furthermore, we find that deposit schemes increase the recycling rate by 5 percentage points as for Plastic and by 15 percentage points as for glass. Furthermore, we find that the characteristics of the waste management system affect the performance of packaging recycling: large systems seem to experience greater challenge, as a one

standard deviation increase in waste generated (+1400 kton) from the mean level decreases recycling rates by 3 percentage points (for all packaging). Higher public expenditure on MSW on the other hand increases packaging recycling rates, as a one standard deviation increase in costs (109 €/ton) from the mean level increases recycling rates by 4 percentage points. Finally, we find that the average of EU waste materials' prices does not affect recycling rates. This result may be dependent on the use of EU-wide average prices, which was included in the model due to the lack of country-level information on the prices of recycled material for the full set of countries considered.

Figure 5 - Predicted recycling rate by packaging collection categories



Analysis of PROs' performance

The recycling and cost KPIs are shown in combination across the different PROs, in order to identify the possible trade-offs between higher costs and recycling results. The most efficient EPR systems are grouped in the first quadrant, as they present both a high recycling KPI and a high cost KPI (i.e. lower costs). On the other hand, the least efficient systems fall in the third quadrant. The results highlight that most of the PROs have a relatively good performance in the combination of the normalized KPIs.

The scatter plots show the value of the mean KPI across all years of observations (left panels of figures 7 to 11). On the other hand, the line plots show the value of the to KPIs over time for each PRO (central and right panels of figures 7 to 11). In this case only a sub-set of the PROs in the "big"

category has been selected as these are the PROs which can be compared more directly to CONAI. CONAI is among the group of best performers in the case of all packaging materials as well as in the management of paper and glass packaging, while it is relatively less well positioned as for plastic packaging management. The performance of CONAI over time (central and left panels) in shown next to the one of a group of comparable PROs[10]. The KPI which improves the position of the Italian system with respect to its peers is the cost KPI, meaning that a similar recycling rate is associated with different levels of cost efficiency.

Similarly to the regression analysis, we find that "Single" PROs are associated with a higher performance on both the cost KPI and the recycling rate KPI, this is mainly true when all packaging materials are considered. Particularly, this partial metric highlights that the divergence between the performance of the two groups is larger for the latter KPI and for the paper and glass streams (figures 8 and 10). The performance across groups is more similar in the case of the plastic waste stream (figure 9), a result which is in line with regression analysis findings where only small and weakly statistically significant differences could be found across "Single" and "Multiple" systems. From the point of view of **effectiveness** regression results show that "Single" EPR systems increase the recycling rate with respect to "Multiple" EPR systems. The partial benchmark analysis confirms this result: i.e. "Single" PROs, overall, achieve better results in term of recycling rates. From the point of view of **efficiency** th benchmark analysis finds that financial resources are used more efficiently in Single systems, always located in the higher-right areas of the KPI graphs.

The distinction of PROs' KPI performance over different groups leads to less straightforward results. We compare the mean score over time in two cases (figure 7): i) the three groups of operational responsibility for household packaging collection (Local Authorities, EPR or both Local Authorities and EPR) and ii) the three groups of Member States based on the entrance of the country in the EU, a proxy of the degree of maturity of the EPR system in place (the categories are "before 2004", in 2004 or in 2007). The partial metric adopted cannot disentangle the role of different operational responsibility schemes, as opposed to the more comprehensive regression analysis. On the other hand, we find evidence that newer EPR systems (those put in place in the countries which entered the EU in 2007), have a different mean score over time with respect to the other systems: the cost KPI in newer systems is relatively higher, meaning that EPR costs are on average lower in this group of PROs. At the same time, the group of newer PROs is characterized by a lower score in the recycling rate KPI. The difference in both cases was more evident in the first years (2014 to 2017), while it has narrowed down in recent years (2018 and 2019).

[10]The value for ECOEMBES in the case of "all packaging" includes the data of ECOVIDRIO, managing glass packaging, in order to allow for a comparability across systems.

Figure 6 - KPI by PROs categories (country and competition class) - All packaging

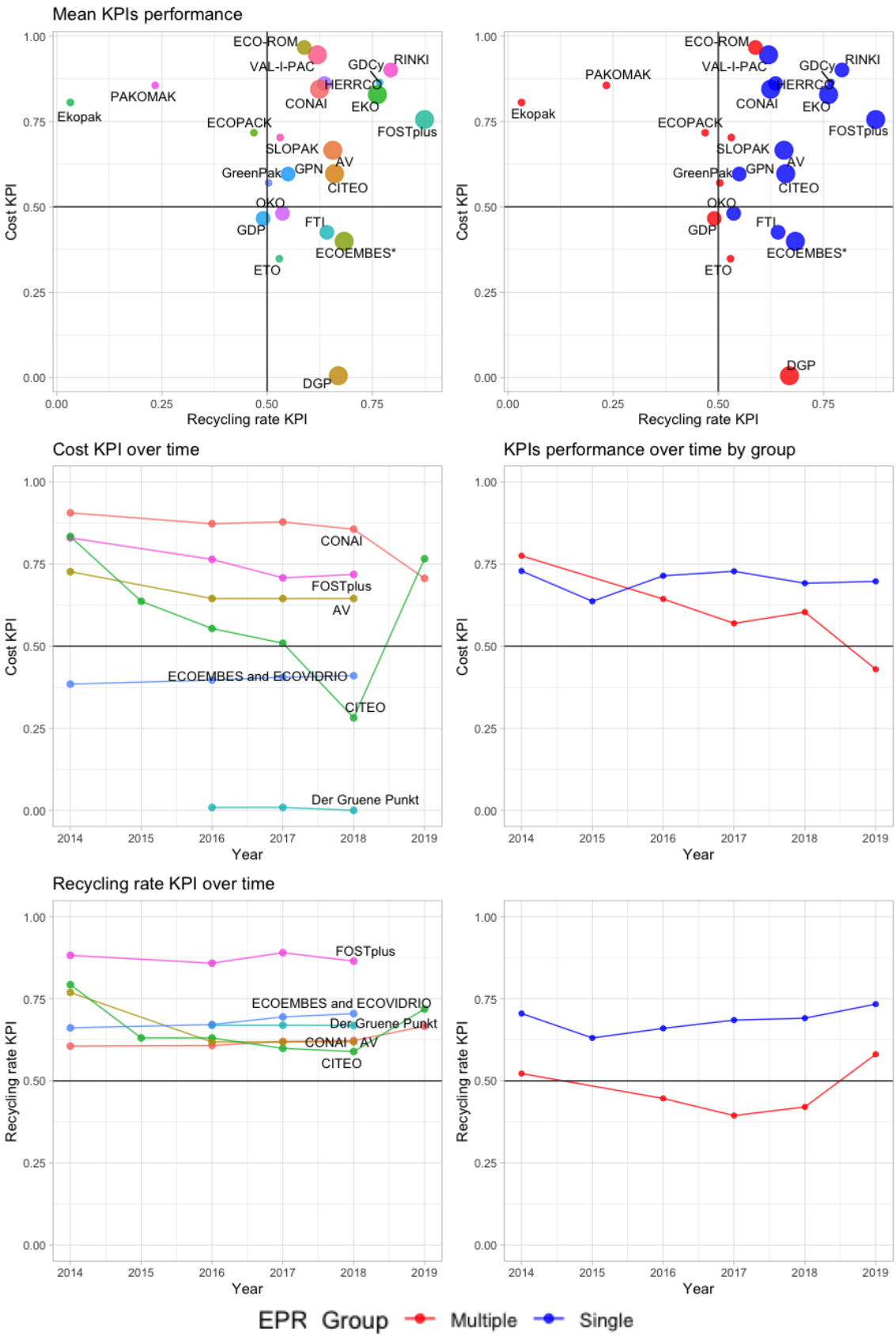
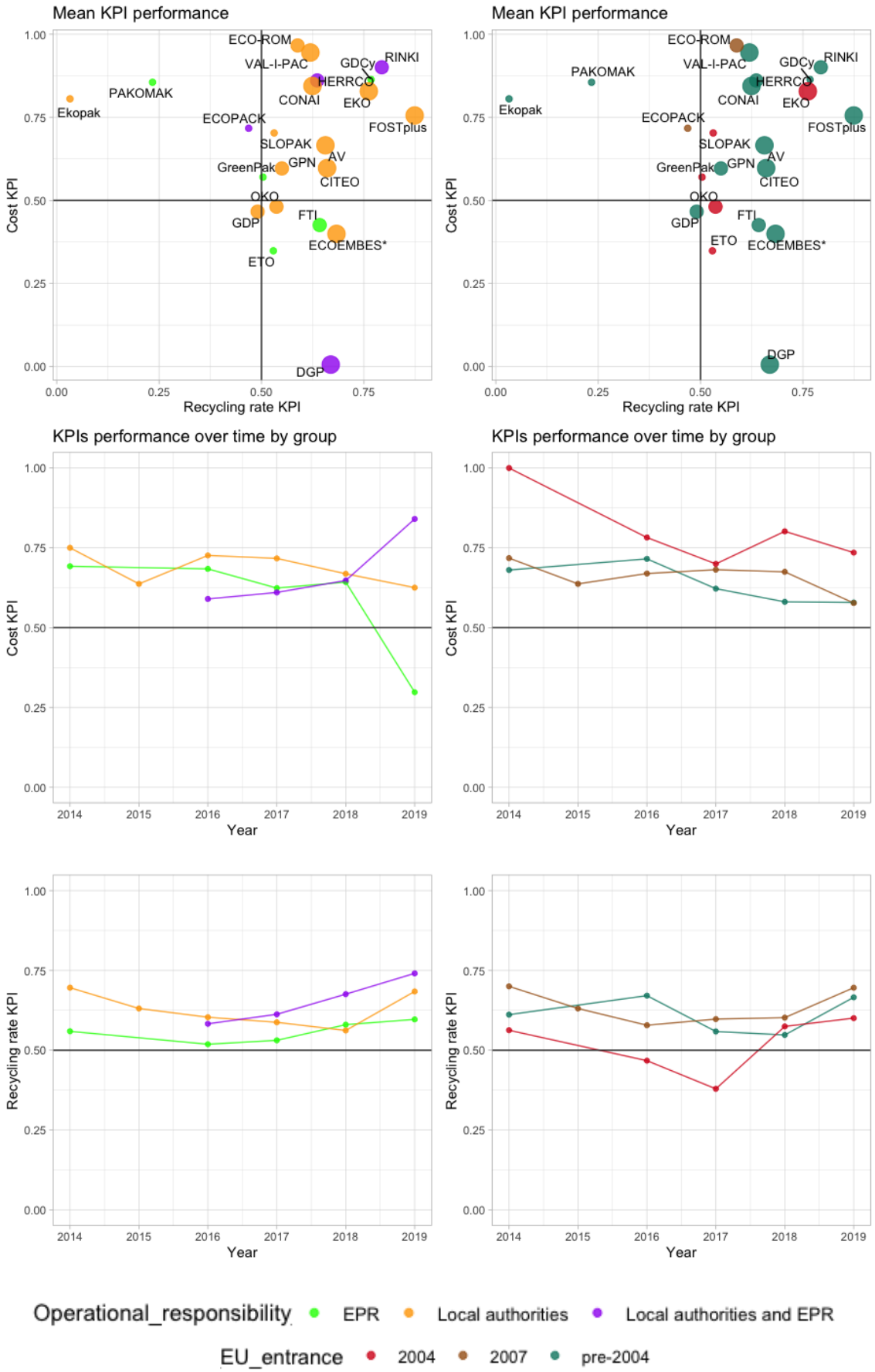


Figure 7 - KPI by PROs categories (collection and entrance in EU) - All packaging


Mean KPI performance
Cost KPI
Recycling rate KPI
ECO-ROM
VAL-I-PAC
GDCy
RINKI
HERRCO
CONAI
EKO
PAKOMAK
Ekopak
ECOPACK
FOSTplus
SLOPAK
AV
GPN
GreenPak
CITEO
OKO
GDP
FTI
ECOEMBES*
ETO
DGP
KPIs performance over time by group
Year
Operational_responsibility
EPR
Local authorities
Local authorities and EPR
EU_entrance
2004
2007
pre-2004

As for the paper packaging stream (figure 8), we see a distribution of scores more similar to the one of all materials combined. In particular, CITEO (France) and Der Gruene Punkt (Germany) have the lower score in the cost KPI, while CONAI achieves a strong score in the cost KPI (decreasing over time), although its performance in terms of return rate has been stably around the average. As for the plastic packaging stream (figure 9) shows that most EPR systems perform less efficiently. Most efficient systems are those that handle small absolute volumes of plastic packaging waste, as ECO-RON (Romania), VAL-I-PAC (Belgium, industrial sector) and EKO (Czech Republic). As for the glass packaging stream (figure 10), larger PROs seem to be better positioned than smaller ones, indicating the possibility that economies of scale matters. Fost-Plus (Belgium) is the best positioned, thanks to the very high recycling KPI, while CONAI is among the most virtuous in terms of cost effectiveness with a relatively stable performance across the years.

In order to assess if the main results obtained from the regression analysis can be replicated by the analysis conducted at the level of each PRO, in figures 8 to 10 the KPIs' scatterplots and lineplots by competition group are presented (while figures S3, S4 and S5 in Annex show the value of the KPIs for the other categories).

Figure 8 - KPI by PROs categories (country and competition class) – Paper

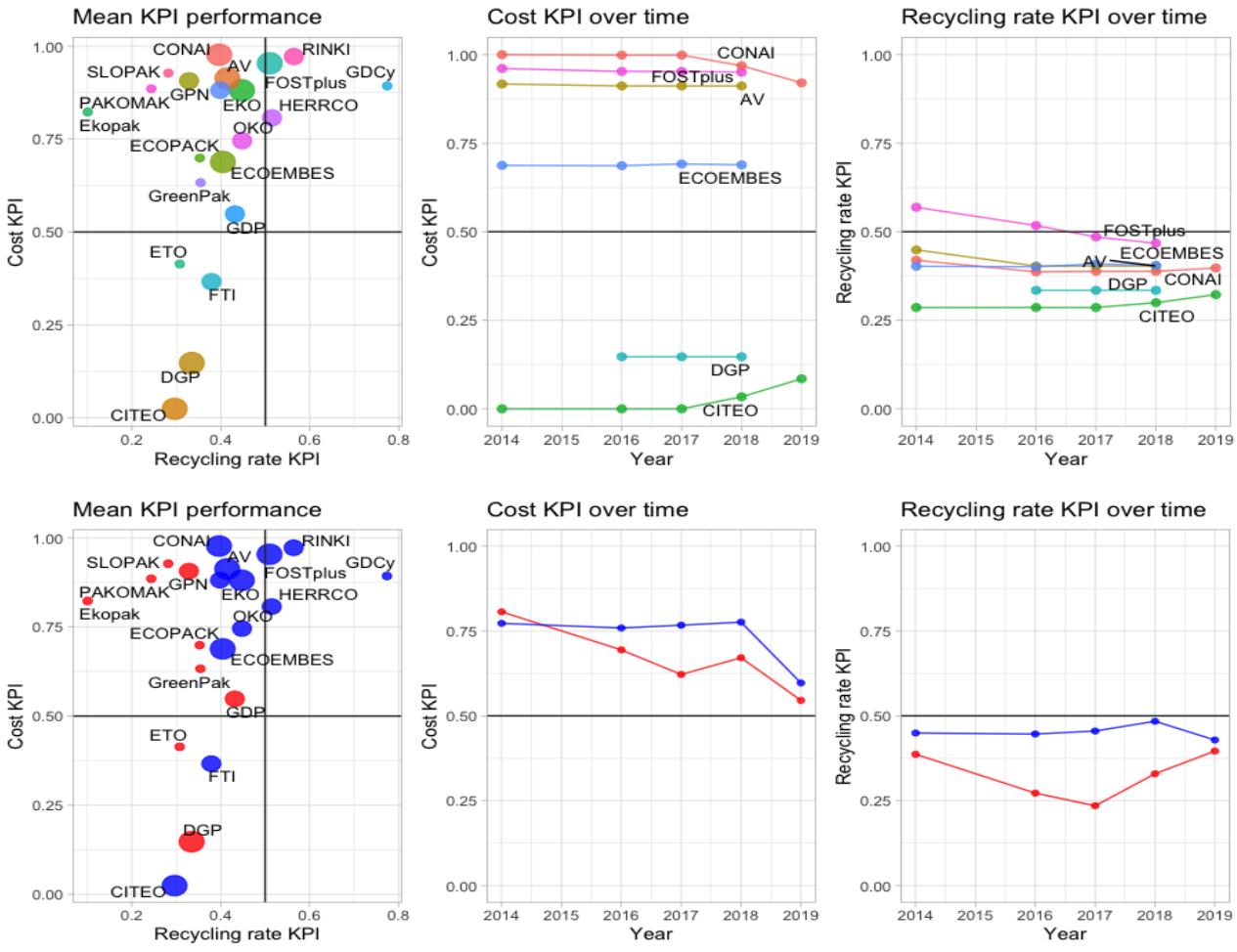
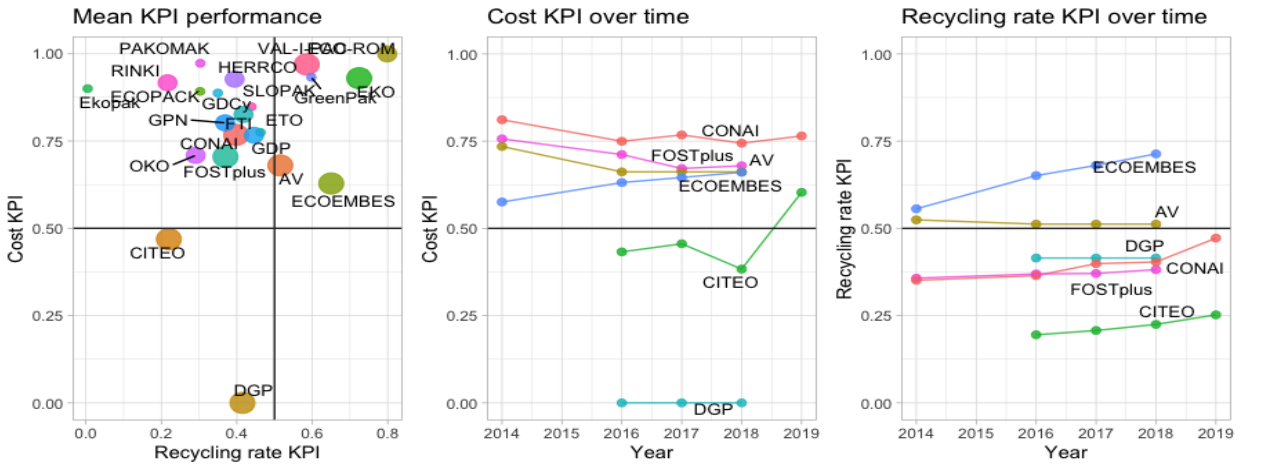


Figure 9 - KPI by PROs categories (country and competition class)– Plastic



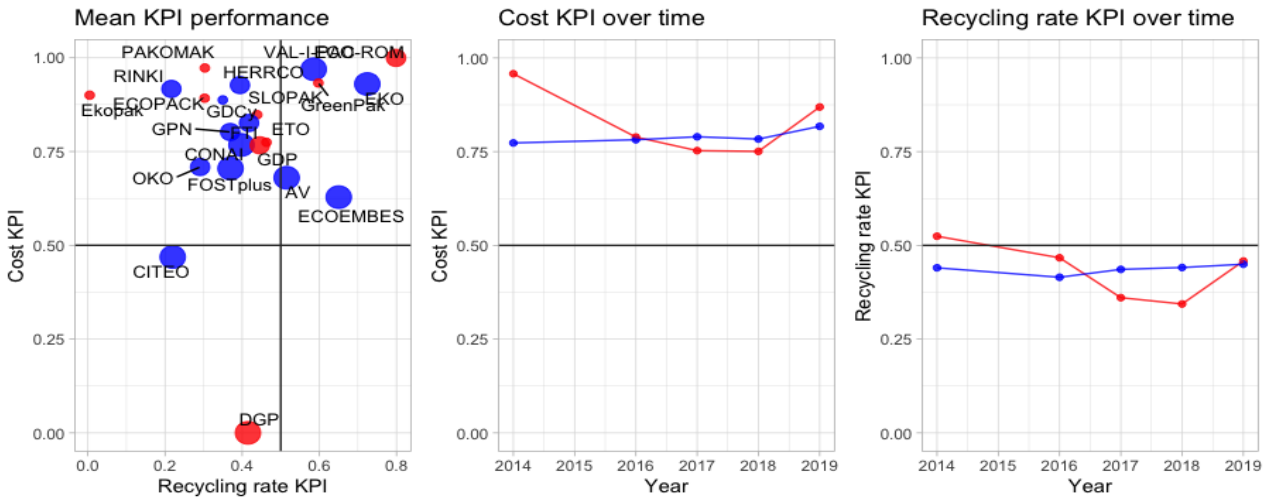
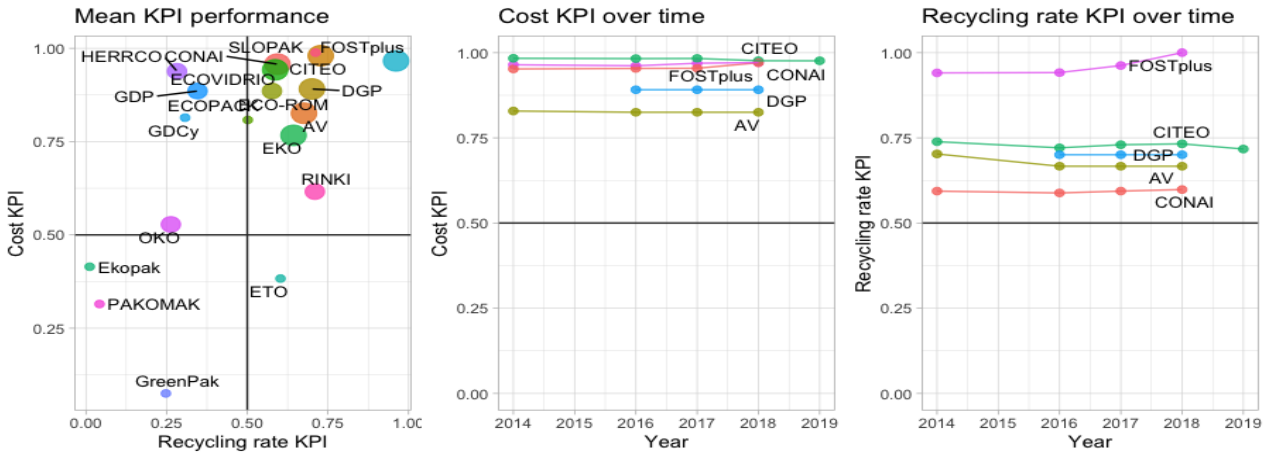
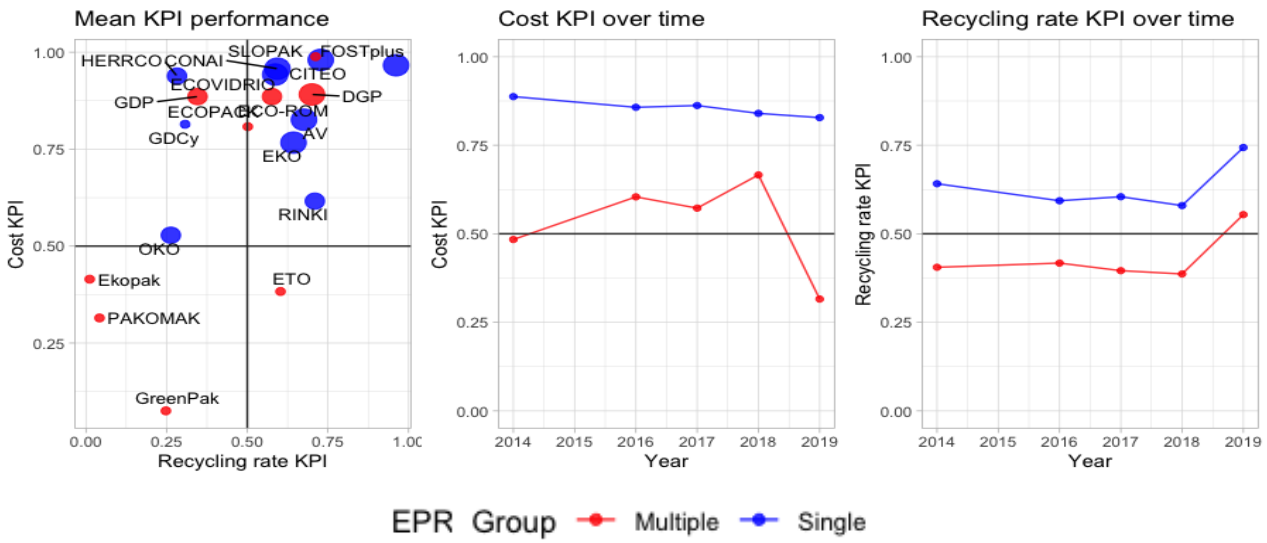


Figure 10 - KPI by PROs categories (country and competition class) – Glass





Ratio analysis

By taking into account the previews analysis, our exploration of PROs' financial performance is evaluated in relation with the operational results – i.e. by comparing the performance of each ratio with the performance in the normalized recycling KPI. Additional results and a graphical representation of the financial ratios can be found in *Annex IV – Ratio Analysis.*

Figure 11 combines six scatterplots, each of which has on the x axis the recycling rate KPI (all materials combined) and on the y axis a different financial ratio obtained through comparable data from ORBIS Bureau van Dijk database. The average values of ORBIS ratios are computed for the period 2010-2019, in order to smooth the impact of one single year on the overall PRO's performance. PROs are grouped based on the two competition classes.

The first two graphs of the figure present profitability ratios. The first is the return on assets (ROA), that is an indicator of how profitable a company is relative to its total assets. ROA gives a manager, investor, or analyst an idea on how efficient a company's management is at using its assets to generate earnings. ROA allows a verification not only on the company's ongoing viability but also of its ability to generate new funds for future investments in order to enhance services for the community (Bartolacci et al., 2018). Although the ROA is traditionally considered satisfactory when it is positive, a value near zero for PROs which operate under a not-for-profit mandate is desirable and, hence, represents a satisfactory financial result. We find that the more the recycling rate KPI increases, the more dispersed are the results of the PROs away from the sector specific equilibrium value (ROA=0). The second ration on profitability is the EBIT margin index, that reflects the amount of self-financing conducted and highlights the part of a business' production value that remains after accounting for operating expenses (production costs and the members' and partners' remuneration).

The ratio tells us how much operating cash is generated for each dollar of revenue earned and can therefore have positive or negative values depending on the net operating profit or loss. Despite most PROs show results in line with no-profit objectives, some also realize profits (even over 10€ of profit every 100€ of turnover) and loss (even over 10€ of loss every 100€ of turnover).

This happens mostly for small PROs (both Single and Multiple), but what is mainly evident is that also the group of big and Single PROs, for high levels of the recycling KPI, deviates from the expected results – CONAI, represented by the green dot, falls within the last category due to a relatively small average loss. The graphs on second row present liquidity ratios on the x axis. Financial independence ratio measures the ability of PROs of not recurring to external debts. CONAI, with respect to the other Single-Big PROs, achieve good results: Sweden Norway, France and Spain, achieving similar recycling rates, present very low financial ratios, underlying they resort more to external sources (their Current Liabilities ORBIS budget item has a greater weight on Total Liabilities – Balance Sheet than that of CONAI). The asset liquidity ratio measures asset flexibility, which is the function of the specific type of activity operated by PROs; service intensive activities require more in terms of current assets. In the last row on left a solvency ratio is presented, the Current ratio, that reveals a PRO's ability to satisfy its current debt and other payables (due within one year) by maximizing current assets on its balance sheet. A company with a Current ratio less than one does not, in many cases, have the capital on hand to meet its short-term obligations if they were all due at once, while a Current ratio greater than one indicates the company has the financial resources to remain in the short-term[11].

The equilibrium value of the Current ratio is 1 but this index must always be compared with sectorial average. A current ratio that is lower than the peers' average may indicate a higher risk of distress or default. Similarly, if a company has a very high current ratio compared to their peer group, it indicates that management may not be using their assets efficiently. Values around the equilibrium are reached mostly by the group of Single-Big PROs and are also associated with higher values of Recycling Rate KPI. Group of Multiple PROs does not perform as much well. In the last row on the right, we present a ratio adapted to the sectoral specificities of the PROs, as we compute the operating revenues (i.e. the turnover) by the total tons of packaging waste recycled by the PROs in a given year. With some exceptions, the graph displays that very high Recycling Rate KPI are generally associated with high Operating Revenues (Turnover) per tons of recycled packaging, which in the case of PROs means that high fees are associated with higher recycling rates. However, this is not a signal of cost-efficiency.

[11] See for instance the discussion in: "https://www.investopedia.com/articles/investing/100313/financial-analysis-solvency-vs-liquidity-ratios.asp"

Figure 11 - Financial ratios and Recycling Rate KPI relationship *The green dot represents CONAI.*

On the other hand, many PROs of the Single-Big group – including CONAI – are able to reach good Recycling KPI by keeping low the operating revenues per tons of recycled tons[12]. From the point of view of the ability to accomplish the desired result (higher recycling rate) with an efficient management of financial resources, the ratio analysis confirms the results obtained from the regression and the KPIs: independently on the ratio analyzed, we identify that big PROs in Single environments are located in the areas of the graphs which coincides with financial results expected from the operation of a not-for-profit business. At the same time the ratio analysis shows that when very high recycling rates are achieved the financial performance of PROs, independently of the group, departs from the results expected by not-for-profit companies – i.e. effectiveness is not always associated with good financial performance.

Conclusions

This report provides an analysis of the operational and economic implications on packaging waste systems' performance, with a focus on EPR schemes and PROs' organizational characteristics.

An econometric analysis and an indicator-based assessment are adopted to provide different measures of the financial and operative performance. The analysis provides a detailed quantification of the cost efficiency and effectiveness of EPR schemes and PROs across different materials, providing in turn valuable insights on how to improve the performance of Member States' EPR systems towards the goals set by the Circular Economy Package.

Our results are only partially comparable with the available literature: the analysis by EC (2014) for instance finds that the best performing schemes are not, in most cases, the most expensive, and that reports that no Single EPR model emerges as the best performing and the most cost-effective. Our results are in accordance with the results of EC (2014) for the general conclusion that a high recycling performance does not necessarily come at the expenses of high costs.

On top of this general result, our study clearly shows that cost-efficiency and cost-effectiveness is mostly associated with EPR schemes that reply on Single environments.

[12] The following caveat should be considered in the analysis of this financial indicator: financial data available from the ORBIS Bureau Van Djik is associated to the budgetary items of a given PRO, but not of the possible parallel materials' consortia that operate under its oversight. In the case for Italy, for instance, the revenues of CONAI do not correspond to the revenues of CONAI and the six materials' consortia. While for Italy and few other countries the data of the revenues for both the PRO and the materials' consortia could be collected, for the majority of the PROs this data is not available. For this reason, we have used only the information of the PRO's budget from Bureau Van Djik, although this could lead to an underestimation of PROs' revenues when these are operating together with materials' consortia.

From the point of view of **effectiveness** - the degree to which this characteristic of the EPR system is successful in producing the desired result, no matter the cost - we find that EPR systems with no competition among PROs are associated with higher recycling rates with respect to EPR systems with competing PROs. Single EPR schemes achieve on average, *ceteris paribus*, higher recycling rates by around 8 percentage points. Results very greatly by material, as Single systems are more effective in recycling paper packaging, Multiple systems are associated with higher glass packaging recycling while no differences are found across the EPR competition groups as for plastic packaging. Performance benchmark analysis based on a set of KPIs confirms the main result – i.e. that "Single" PROs, overall, achieve better results in term of recycling rates. Nonetheless, the ratio analysis underlies that when very high recycling rates are achieved the financial performance of PROs, independently of the group, departs from the expected results of not-for-profit companies – i.e. effectiveness is not always associated with good financial performance.

From the point of view of **efficiency** - the ability to accomplish the desired result (higher recycling rate) with the least amount of money – regression analysis shows that financial resources are used more efficiently in Single systems as this category is always characterized by higher recycling rates associated to a given cost level. We find that increasing costs per capita increases the recycling rate. Different materials are characterized by different functions linking recycling performance to EPR costs: strong saturation effects are found as for glass packaging, while Single systems appear to be the only group achieving high plastics' recycling rates when EPS costs for this material increase above the average level. Coherently, our analysis underscores that plastics' recycling is the sector in which efficiency is lowest across all PRO categories (based on operational KPIs and regressions). Across all packaging materials, higher recycling rates are expected when the operational responsibility of collection falls on local authorities or on both local authorities and EPR systems. Furthermore, mixed collection strategies, comprising both door-to-door and bring point options, and the inclusion of deposits schemes, are associated with higher recycling rates. The quantitative benchmark analysis confirms that financial resources are used more efficiently in Single systems, always located in the higher-right areas of the KPI graphs and independently on the ratio analyzed. The ratio analysis identifies that big PROs in Single environments are located in the areas of the graphs which coincides with financial results expected from the operation of a not-for-profit business.

This analysis finds evidence that EPR systems with a shared responsibility through a Single, non-competitive system can benefit from the presence of a single body that covers the burdens on the producers of the goods, ensuring the collection, transport and treatment of waste. Multiple factors may explain such advantage (OECD, 2016): the homogeneous territorial distribution of operations;

more effective communication between producers, authorities and other actors in the supply chain; reduction of administrative burdens (monitoring and control); optimization of logistics and processing costs (through economies of scale); avoidance of opportunistic behavior that could result in guaranteeing the service only in cases where it is economically convenient (so-called 'cherry picking'). At the same time, it is important to underscore that the restrictions and entry barriers characterizing non-competitive systems must be carefully assessed when the system is launched, and that monitoring should be implemented effectively in order to reduce possible opportunistic behavior of the monopolist in stipulating supply contracts (EUCLID, 2020). When the systems are based on a shared responsibility through a competitive system, with multiple PROs operating in the same market segment, other system mechanisms may be put in place to ensure a homogeneous territorial distribution of operations as well as the avoidance of opportunistic behaviors. The institution of a coordination entity for the collective systems can be seen a valuable option to this aim. According to the OECD, competition authorities could help to ensure that PROs do not abuse market power through excessive or opaque pricing, to require the PRO to contract out collection and recycling services on a competitive basis and to establish contracts that are not unduly long (OECD, 2016). A coordination entity is present for packaging EPR in The Netherlands and Norway (both non-competitive systems) and, from 2019, in Germany (competitive system). The narrow adoption of a coordination entity in the European EPR systems for packaging waste management, in particular in combination with a non-competitive environment, has limited the inclusion of this factor in the empirical investigation conducted. An assessment of the impacts of the recent introduction of such regulation on the German system is considered an interesting case for future analysis.

The analysis conducted on the tariff schemes adopted by the PROs through an ad-hoc survey (see Annex V) finds that some PROs promote material efficiency and/or waste prevention through their fees for packaging put on the market. Others are planning an eco-modulation approach while some, however, have no plans in this direction or design their fees just to cover operational costs. In some cases, the reason for such approach is that PROs have concerns about legal challenges. Recyclability of materials and the share of recycled materials hardly play in setting the fees of the packaging put on the market. These are important elements, that should be considered stronger in the modulation of fees to foster recyclability already in the design phase and increase the share of recycled waste, thus making an active contribution to waste prevention through pricing. Regarding the factors influencing the fees for collected and recovered packaging material, the answers show that the quality of materials is especially relevant for pricing, which is beneficial in terms of circularity. Meanwhile, other factors are not comprehensively addressed, showing that there is still extensive potential for improvement to ensure a more circular path for the waste system.

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Annex I – PROs classification (in 2018)

Table S1

Country	PRO	Market Structure	Dimensional Group	Operational responsibility hh_collection	Financial Resp.	Scope
Poland	REPOKOL	Competition	Big	EPR	Shared	All Packaging
Germany	DER GRUNE PUNKT (DGP)	Competition	Big	L.a. & EPR	Full	All Packaging
Austria	ARAPLUS	Competition	Medium	EPR	Full	Households
Portugal	PONTO VERDE (GDP)	Competition	Medium	L.a.	Shared	All Packaging
Romania	ECO-ROM	Competition	Medium	L.a.	Shared	All Packaging
Slovakia	ENVI-PAK	Competition	Medium	L.a.	Shared	All Packaging
Estonia	ETO	Competition	Small	EPR	Shared	All Packaging
Macedonia	PAKOMAK	Competition	Small	EPR	Full	All Packaging
Malta	GREEN PAK	Competition	Small	EPR	Full	All Packaging
Serbia	SEKOPAK	Competition	Small	EPR		Households
Bosnia Herzegovina	EKOPAK	Competition	Small	L.a.	Full	Households
Lithuania	VŠĮ ŽALIASIS TAŠKAS	Competition	Small	L.a.	Full	All Packaging
Slovenia	SLOPAK	Competition	Small	L.a.	Shared	All Packaging
Bulgaria	ECOPACK	Competition	Small	L.a. & EPR	Full	
Latvia	LATVIJAS ZAĻAIS PUNKTS	Competition	Small	L.a. & EPR	Full	All Packaging
Belgium	VALIPAC	No-Competition	Big	L.a.	Full	All Packaging
Czech Republic	EKO	No-Competition	Big	L.a.	Full	All Packaging
France	CITEO	No-Competition	Big	L.a.	Shared	All Packaging
Italy	CONAI	No-Competition	Big	L.a.	Shared	All Packaging
Netherlands	AV	No-Competition	Big	L.a.	Shared	All Packaging
Spain	ECOEMBES	No-Competition	Big	L.a.	Shared	All Packaging
Sweden	FTI	No-Competition	Medium	EPR	Full	All Packaging
Croatia	EKO-OZRA	No-Competition	Medium	L.a.	Tax	Households
Hungary	OKO	No-Competition	Medium	L.a.	Tax	Households
Norway	GRUNE PUNKT (GPN)	No-Competition	Medium	L.a.	Shared	All Packaging
Finland	RINKI	No-Competition	Medium	L.a. & EPR	Full	All Packaging
Greece	HERRCO	No-Competition	Medium	L.a. & EPR	Shared	All Packaging
Cyprus	GREEN DOT (GDCy)	No-Competition	Small	EPR	Full	Households
Luxembourg	VALORLUX	No-Competition	Small	L.a.	Full	All Packaging

Annex II – Additional results

Table S2: Value of KPI by PRO

Country	PRO	Dimensional_Group	KPI_recycle	KPI_cost
Belgium	FOSTplus	Big	0,87	0,76
Belgium	VAL-I-PAC	Big	0,62	0,94
Bosnia and Herzegovina	Ekopak	Small	0,03	0,81
Bulgaria	ECOPACK	Small	0,47	0,72
Cyprus	GDCy	Small	0,77	0,86
Czech Republic	EKO	Big	0,76	0,83
Estonia	ETO	Small	0,53	0,35
Finland	RINKI	Medium	0,79	0,90
France	CITEO	Big	0,66	0,60
Germany	DGP	Big	0,67	0,01
Greece	HERRCO	Medium	0,64	0,86
Italy	CONAI	Big	0,62	0,84
Macedonia	PAKOMAK	Small	0,23	0,86
Malta	GreenPak	Small	0,50	0,57
Netherlands	AV	Big	0,66	0,67
Norway	GPN	Medium	0,55	0,60
Portugal	GDP	Medium	0,44	0,59
Romania	ECO-ROM	Medium	0,59	0,97
Slovenia	SLOPAK	Small	0,53	0,70
Spain	ECOEMBES	Big	0,70	0,07
Spain	ECOVIDRIO	Big	0,66	0,98
Sweden	FTI	Medium	0,64	0,43

Table S3: All packaging

	Dependent variable:				
	Waste_recycled_percentage				
	(1)	(2)	(3)	(4)	(5)
EPR_Group-Single	7.904***	8.062***	8.918***	3.133	-9.459
	(1.235)	(1.221)	(1.380)	(2.275)	(5.968)
Role_of_PROHouseholds	-3.662**	-3.986**	-3.007	-1.688	3.773
	(1.633)	(1.652)	(2.146)	(2.253)	(2.910)
Operational_responsibility_hh_collectionLocal authorities	6.769***	5.584***	6.197***	3.348*	4.768***
	(1.454)	(1.473)	(1.543)	(1.705)	(1.715)
Operational_responsibility_hh_collectionLocal authorities and EPR	5.437***	6.959***	7.261***	6.834***	8.290***
	(1.840)	(1.790)	(1.814)	(1.760)	(2.030)
epr_cost_per_capita	0.413***	0.475***	0.288		
	(0.094)	(0.098)	(0.372)		
I(epr_cost_per_capita2)			0.010		
			(0.016)		
collection_strategy_simpledoor_to_door		1.956	2.096	1.500	-2.389
		(1.611)	(1.657)	(1.529)	(2.005)
collection_strategy_simplemixed		6.835***	7.355***	6.916***	4.900***
		(1.321)	(1.379)	(1.453)	(1.643)
waste_generated_kton			-0.001	-0.002***	-0.002***
			(0.001)	(0.001)	(0.001)
public_exp_per_ton_msw				0.032***	0.025***
				(0.008)	(0.009)
trend	0.351	0.458**	0.448**	0.574***	0.622***
	(0.219)	(0.224)	(0.224)	(0.218)	(0.215)
GDP_Capita					-0.002
					(0.038)
pop_density_classpop_density_low					2.348
					(2.077)
pop_density_classpop_density_median					-1.979
					(2.335)
EPR_GroupMultiple:epr_cost_per_capita				0.041	-1.679
				(0.153)	(1.095)
EPR_GroupSingle:epr_cost_per_capita				0.641***	4.453**
				(0.202)	(2.141)
EPR_GroupMultiple:I(epr_cost_per_capita2)					0.115
					(0.117)
EPR_GroupSingle:I(epr_cost_per_capita2)					-0.352*
					(0.196)
EPR_GroupMultiple:I(epr_cost_per_capita3)					-0.002
					(0.003)
EPR_GroupSingle:I(epr_cost_per_capita3)					0.009*
					(0.005)
Constant	48.797***	44.953***	44.927***	45.929***	49.644***

	(1.771)	(1.913)	(2.237)	(2.259)	(4.013)
Observations	188	167	167	158	158
R^2	0.416	0.500	0.505	0.583	0.642
Adjusted R^2	0.396	0.474	0.474	0.551	0.595
Residual Std. Error	7.679 (df = 181)	7.332 (df = 158)	7.336 (df = 156)	6.920 (df = 146)	6.575 (df = 139)
F Statistic	21.473*** (df = 6; 181)	19.727*** (df = 8; 158)	15.944*** (df = 10; 156)	18.546*** (df = 11; 146)	13.819*** (df = 18; 139)
Note:					*p**p***p<0.01

Table S4: Paper

	Dependent variable:					
	Waste_recycled_percentage					
	(1)	(2)	(3)	(4)	(5)	(6)
EPR_GroupSingle	10.005***	10.627***	9.942***	11.462***	10.427***	10.056***
	(1.757)	(1.793)	(1.520)	(1.656)	(2.380)	(3.005)
Role_of_PROHouseholds	-4.398**	-7.308***	-5.876**	-3.174	-4.973*	-3.710
	(2.039)	(2.526)	(2.296)	(2.571)	(2.729)	(2.745)
Operational_responsibility_hh_collectionLocal authorities	0.713	1.515	-0.292	1.330	2.078	1.008
	(1.677)	(1.756)	(1.853)	(1.777)	(1.890)	(1.857)
Operational_responsibility_hh_collectionLocal authorities and EPR	8.319***	8.425***	7.505***	7.133***	9.212***	7.035***
	(2.144)	(2.179)	(2.158)	(2.091)	(2.160)	(2.109)
epr_cost_per_capita		0.646**	-1.701**	-1.985**		
		(0.321)	(0.777)	(0.892)		
I(epr_cost_per_capita2)			0.181***	0.244***		
			(0.063)	(0.069)		
collection_strategy_simpledoor_to_door	0.484	2.844	-1.077	-1.277	3.167	-1.356
	(2.046)	(2.347)	(1.948)	(2.510)	(2.327)	(2.556)
collection_strategy_simplemixed	9.996***	10.671***	7.949***	9.109***	11.788***	9.303***
	(1.584)	(1.632)	(1.633)	(1.785)	(1.678)	(2.095)
`co-mingled`yes	-1.027	-1.695	-2.410		-2.776	
	(2.070)	(2.108)	(2.091)		(2.152)	
waste_price_eu	0.081	0.080	0.086	0.095*	0.077	0.095*
	(0.057)	(0.059)	(0.058)	(0.055)	(0.058)	(0.056)
waste_generated_kton				-0.003***	-0.002**	-0.002***
				(0.001)	(0.001)	(0.001)
GDP_Capita	-0.022	-0.053		-0.008	-0.054*	-0.006
	(0.028)	(0.032)		(0.033)	(0.033)	(0.035)
trend	0.866***	0.773***	0.751***	0.811***	0.833***	0.835***
	(0.255)	(0.260)	(0.255)	(0.246)	(0.257)	(0.250)
EPR_GroupMultiple:epr_cost_per_capita					0.547	-2.271**
					(0.526)	(1.024)
EPR_GroupSingle:epr_cost_per_capita					1.184***	-1.586
					(0.382)	(1.472)
EPR_GroupMultiple:I(epr_cost_per_capita2)						0.251***

						(0.080)
EPR_GroupSingle:I(epr_cost_per_capita2)						0.219*
						(0.113)
Constant	58.069***	58.923***	59.873***	58.523***	59.023***	58.975***
	(8.605)	(8.918)	(8.630)	(8.408)	(8.807)	(8.483)
Observations	173	168	168	168	168	168
R^2	0.457	0.469	0.487	0.526	0.496	0.527
Adjusted R^2	0.423	0.432	0.451	0.489	0.453	0.484
Residual Std. Error	8.494 (df = 162)	8.524 (df = 156)	8.379 (df = 156)	8.080 (df = 155)	8.360 (df = 154)	8.122 (df = 153)
F Statistic	13.610*** (df = 10; 162)	12.530*** (df = 11; 156)	13.462*** (df = 11; 156)	14.334*** (df = 12; 155)	11.651*** (df = 13; 154)	12.189*** (df = 14; 153)
Note:						*p**p***p<0.01

Table S5: Glass

	Dependent variable:					
	Waste_recycled_percentage					
	(1)	(2)	(3)	(4)	(5)	(6)
EPR_GroupSingle	-8.062**	-12.09***	-12.09***	-14.51***	-23.74***	-42.71***
	(3.330)	(3.412)	(3.424)	(3.585)	(4.265)	(5.805)
Role_of_PROHouseholds	3.220	0.153	0.206	-2.664	-2.474	-0.072
	(4.586)	(4.546)	(4.749)	(4.900)	(4.579)	(4.523)
Operational_responsibility_hh_collectionLocal authorities	25.293***	22.012***	21.979***	20.901***	17.288***	19.524***
	(3.302)	(3.411)	(3.518)	(3.518)	(3.430)	(3.259)
Operational_responsibility_hh_collectionLocal authorities and EPR	17.610***	12.598***	12.596***	11.842***	9.253**	15.240***
	(3.602)	(4.017)	(4.032)	(4.003)	(3.890)	(3.980)
epr_cost_per_capita		-6.826***	-6.579	-5.213		
		(2.152)	(6.493)	(6.454)		
I(epr_cost_per_capita2)			-0.077	-0.781		
			(1.903)	(1.913)		
collection_strategy_simpledoor_to_door	0.826	2.153	2.059	-1.640	-3.249	-1.590
	(4.879)	(4.893)	(5.431)	(5.665)	(4.872)	(5.150)
collection_strategy_simplemixed	-2.579	-2.970	-3.023	-8.965*	-9.781**	-6.399
	(3.909)	(4.015)	(4.240)	(5.096)	(4.573)	(4.600)
depositYes	12.716***	16.817***	16.798***	20.295***	23.043***	25.937***
	(4.264)	(4.922)	(4.962)	(5.194)	(5.014)	(4.762)
GDP_Capita	0.470***	0.546***	0.546***	0.547***	0.524***	0.545***
	(0.054)	(0.056)	(0.057)	(0.057)	(0.054)	(0.051)
waste_generated_kton				0.005**	0.006**	0.003
				(0.002)	(0.002)	(0.002)
waste_price_eu	-0.171	-0.132	-0.131	-0.179	-0.193	-0.163
	(0.467)	(0.459)	(0.461)	(0.456)	(0.436)	(0.409)
trend	0.969*	1.251**	1.251**	1.310**	1.314**	1.051**
	(0.551)	(0.544)	(0.546)	(0.540)	(0.516)	(0.488)

EPR_GroupMultiple:epr_cost_per_capita					-10.967***	-31.419***
					(2.265)	(7.438)
EPR_GroupSingle:epr_cost_per_capita					2.367	37.765***
					(3.449)	(12.072)
EPR_GroupMultiple:I(epr_cost_per_capita2)						6.293***
						(2.101)
EPR_GroupSingle:I(epr_cost_per_capita2)						-17.308***
						(5.411)
Constant	9.375	10.492	10.445	13.663	22.856	25.699
	(22.032)	(21.796)	(21.906)	(21.714)	(20.870)	(19.723)
Observations	155	152	152	152	152	152
R^2	0.547	0.588	0.588	0.600	0.635	0.683
Adjusted R^2	0.516	0.555	0.552	0.562	0.600	0.648
Residual Std. Error	14.289 (df = 144)	13.813 (df = 140)	13.862 (df = 139)	13.705 (df = 138)	13.094 (df = 138)	12.291 (df = 136)
F Statistic	17.394*** (df = 10; 144)	18.132*** (df = 11; 140)	16.503*** (df = 12; 139)	15.908*** (df = 13; 138)	18.442*** (df = 13; 138)	19.514*** (df = 15; 136)
Note:						*p**p***p<0.01

Table S6: Plastic

	Dependent variable:					
	Waste_recycled_percentage					
	(1)	(2)	(3)	(4)	(5)	(6)
EPR_GroupSingle	1.506	1.197	1.647	1.671	-1.056	-1.481
	(1.912)	(1.918)	(1.912)	(2.078)	(2.517)	(3.013)
Role_of_PROHouseholds	-8.736***	-9.374***	-10.496***	-8.728***	-10.917***	-14.028***
	(2.413)	(2.589)	(2.623)	(2.456)	(2.850)	(2.777)
Operational_responsibility_hh_collectionLocal authorities	8.435***	8.222***	8.161***	8.483***	6.158***	4.323
	(1.950)	(1.970)	(1.951)	(1.940)	(2.340)	(2.639)
Operational_responsibility_hh_collectionLocal authorities and EPR	1.538	0.566	-0.560	0.498	-0.129	-1.858
	(2.365)	(2.384)	(2.426)	(2.229)	(2.436)	(2.354)
epr_cost_per_capita		-0.070	-0.747*	-0.682*		
		(0.198)	(0.388)	(0.388)		
I(epr_cost_per_capita2)			0.037**	0.037*		
			(0.018)	(0.019)		
collection_strategy_simpledoor_to_door	3.399	3.985*	3.847*	2.890	4.267**	3.799*
	(2.089)	(2.111)	(2.092)	(1.912)	(2.136)	(1.951)
collection_strategy_simplemixed	-3.849	-3.308	-2.507	-3.477	-1.960	0.735
	(2.373)	(2.407)	(2.416)	(2.390)	(2.853)	(2.653)
deposityes	5.520***	6.414***	5.528**	5.067**	6.605***	4.123*
	(2.094)	(2.183)	(2.206)	(2.387)	(2.305)	(2.327)
`co-mingled`yes	0.390	1.959	2.330		2.136	
	(2.017)	(2.075)	(2.063)		(2.132)	
GDP_Capita	-0.072**	-0.077**	-0.063*	-0.064*	-0.093**	-0.067

	(0.035)	(0.037)	(0.038)	(0.038)	(0.040)	(0.045)
waste_generated_kton				-0.001	-0.0005	-0.001
				(0.002)	(0.002)	(0.002)
waste_price_eu	0.006	0.008	0.007	0.007	0.010	0.012
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
trend	1.319***	1.346***	1.308***	1.301***	1.361***	1.269***
	(0.272)	(0.276)	(0.274)	(0.275)	(0.276)	(0.266)
EPR_GroupMultiple:epr_cost_per_capita					-0.243	-1.814***
					(0.255)	(0.536)
EPR_GroupSingle:epr_cost_per_capita					0.457	-1.448
					(0.394)	(1.269)
EPR_GroupMultiple:I(epr_cost_per_capita2)						0.074***
						(0.025)
EPR_GroupSingle:I(epr_cost_per_capita2)						0.168**
						(0.078)
Constant	31.575***	30.960***	31.783***	32.806***	32.926***	36.563***
	(7.902)	(7.919)	(7.852)	(7.852)	(7.994)	(8.270)
Observations	175	170	170	170	170	170
R^2	0.340	0.361	0.377	0.372	0.371	0.425
Adjusted R^2	0.296	0.312	0.325	0.320	0.315	0.369
Residual Std. Error	9.099 (df = 163)	9.027 (df = 157)	8.939 (df = 156)	8.972 (df = 156)	9.008 (df = 155)	8.645 (df = 154)
F Statistic	7.640*** (df = 11; 163)	7.377*** (df = 12; 157)	7.260*** (df = 13; 156)	7.117*** (df = 13; 156)	6.539*** (df = 14; 155)	7.579*** (df = 15; 154)

Note: *p**p***p<0.01

Annex III – Additional results of regressions and KPIs

Figure S1 - Predicted recycling rate of different materials by packaging collection (operational responsibility and collection type)

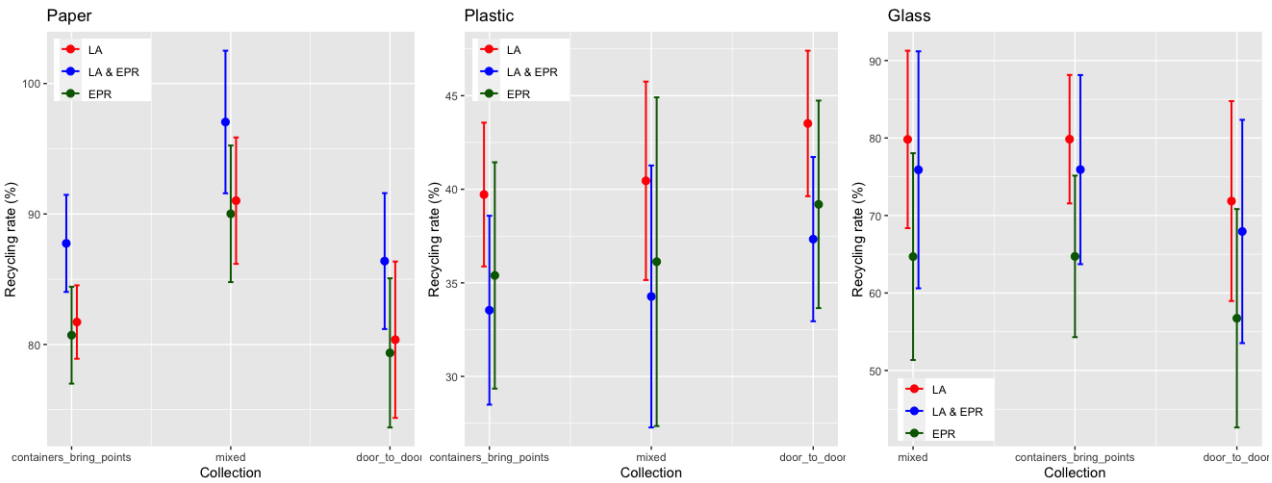


Figure S2 - Predicted recycling rate of different materials by packaging collection (collection type and presence of deposit)

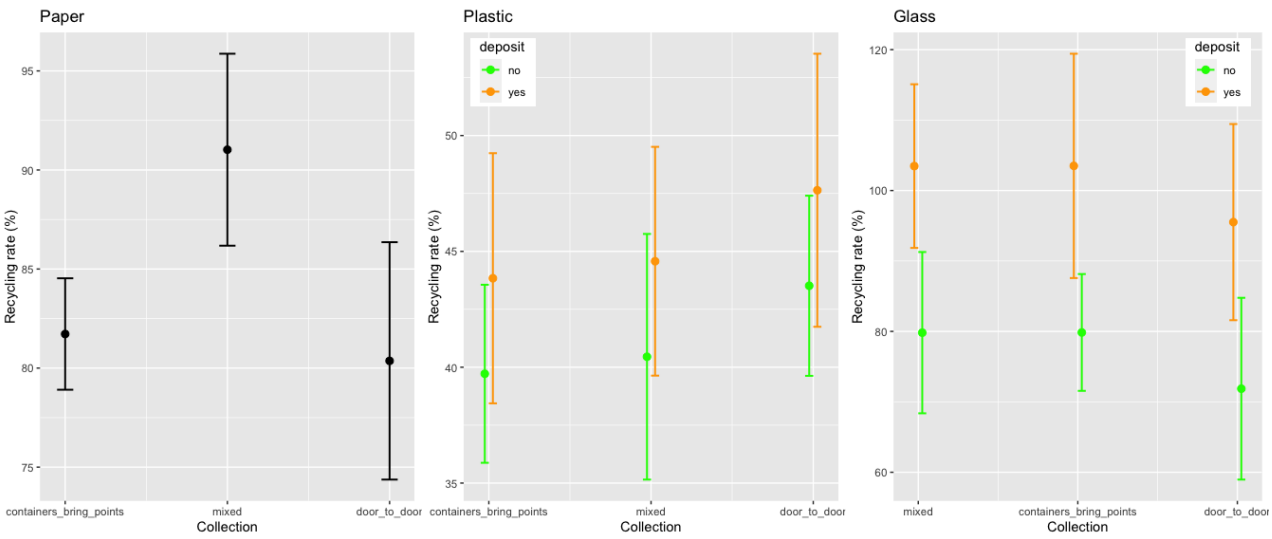


Figure S3 – KPIs of plastic recycling

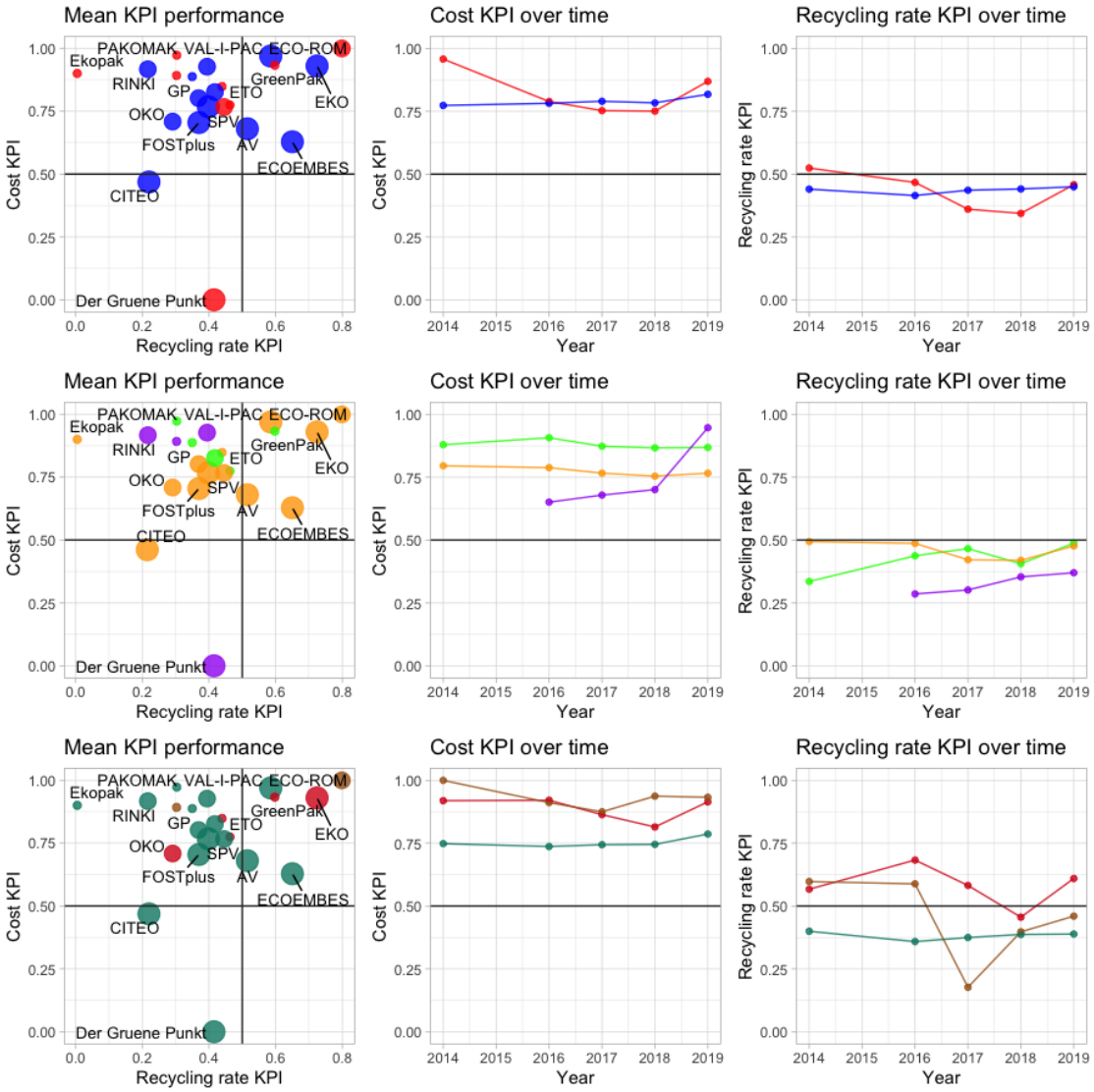


Figure S3 – KPIs of glass recycling

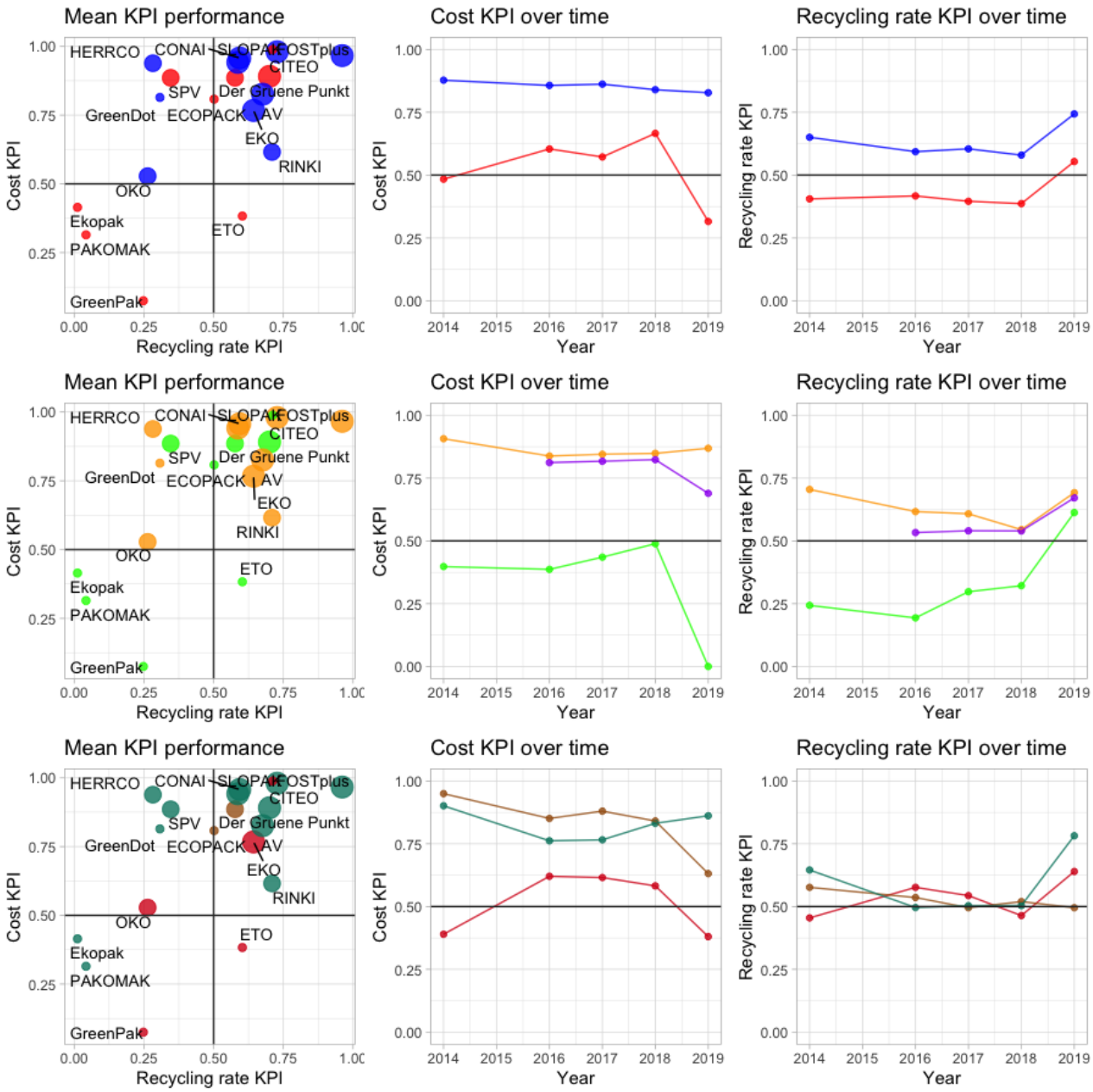
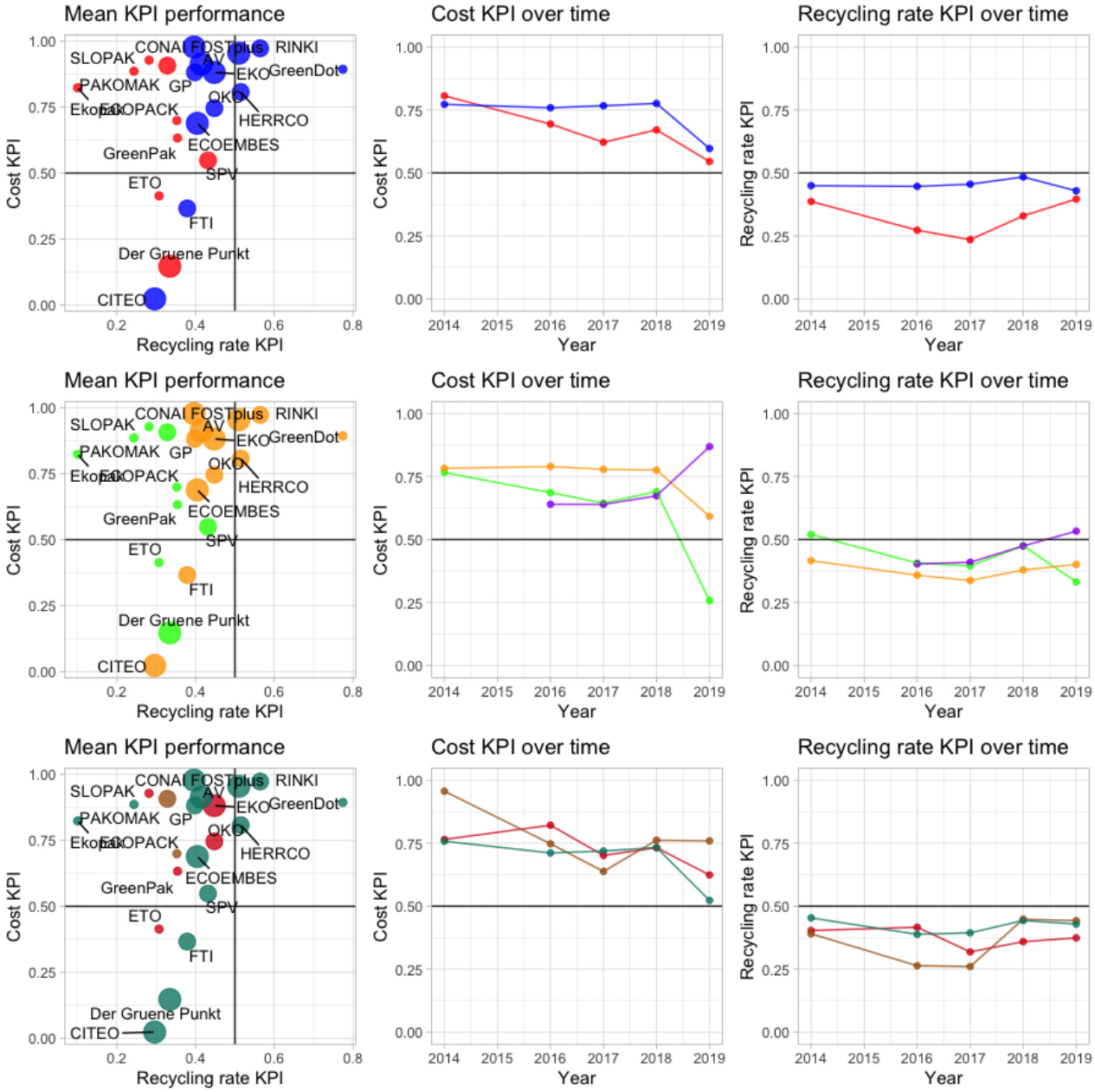


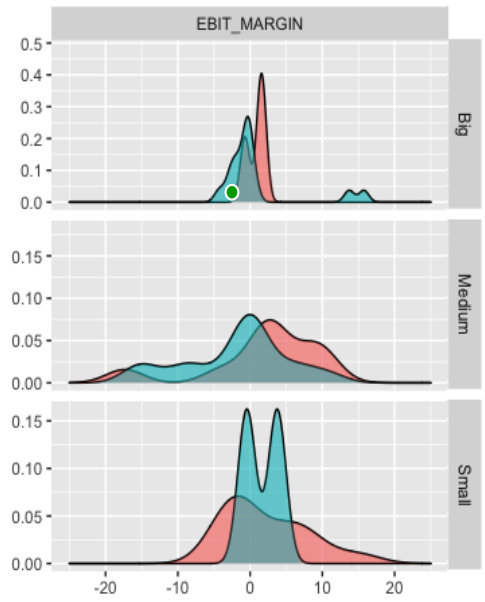
Figure S4 – KPIs of paper recycling

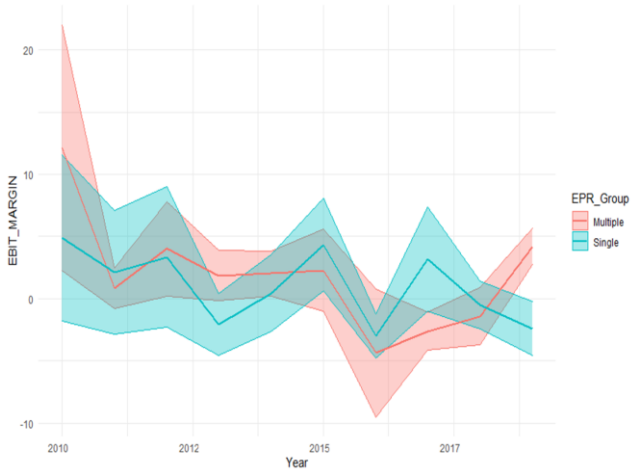


Annex IV – Ratio Analysis

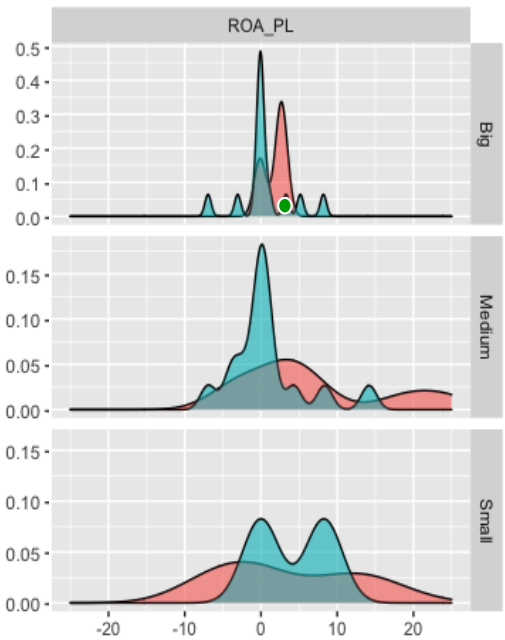
Profitability

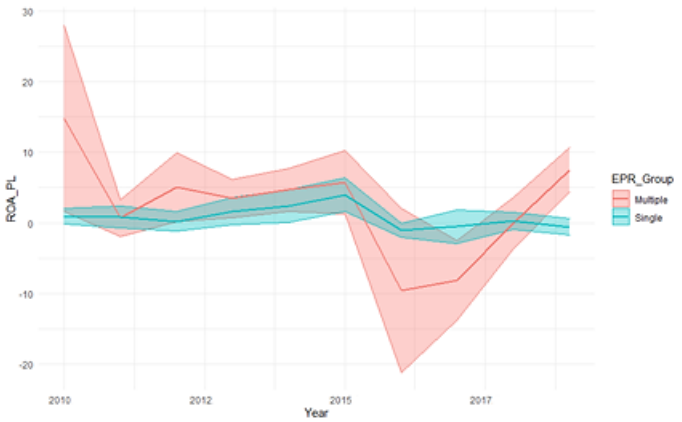
$$EBIT\ margin = \frac{EBIT}{\substack{Operating\ revenue \\ (turnover)}}\ \%$$





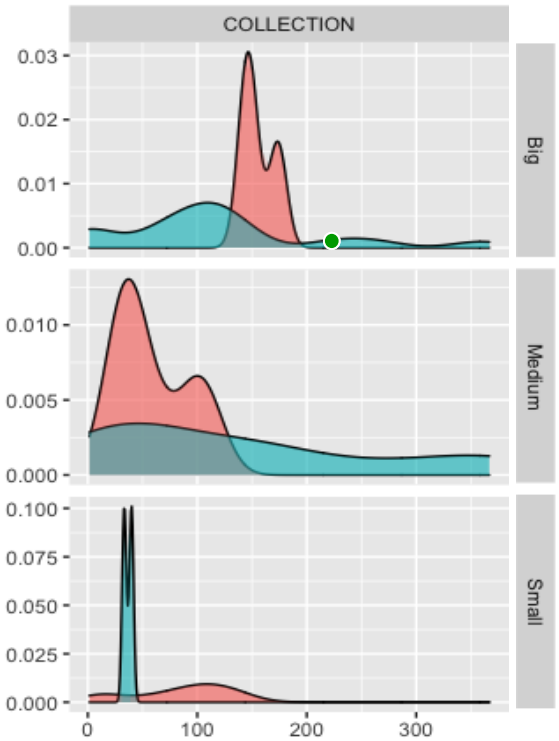
$$ROA = \frac{PorL\ before\ tax}{Total\ assets}\ \%$$

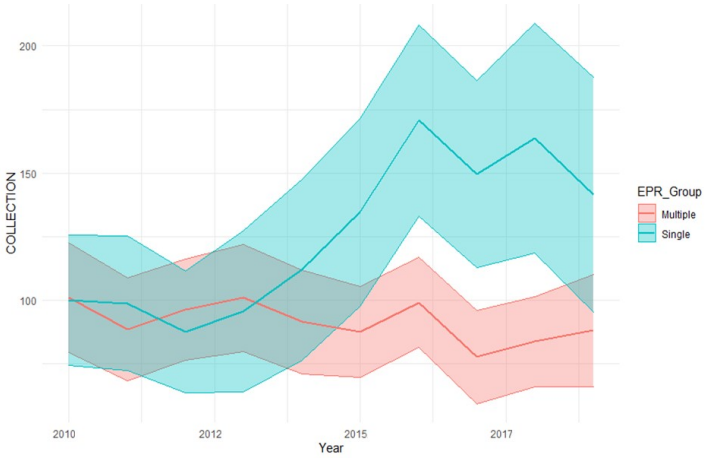




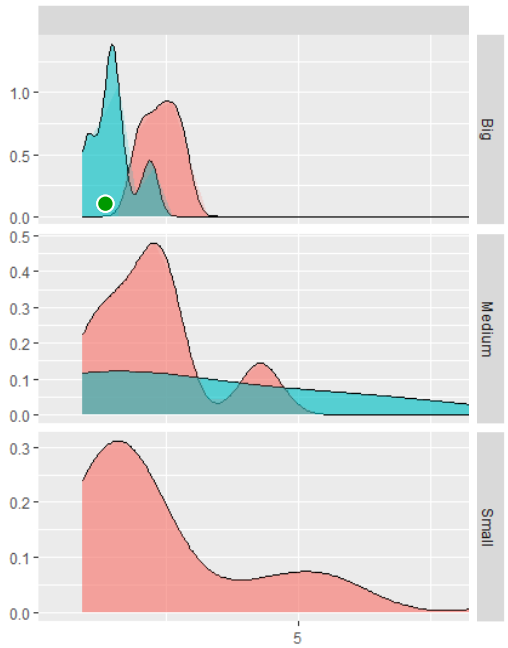
Solvency

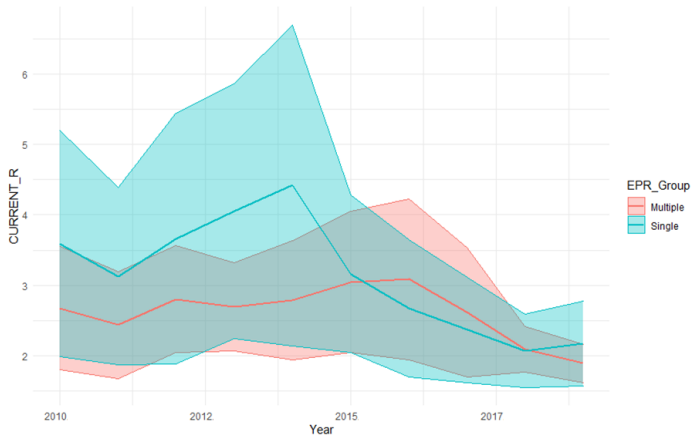
$$Collection\ period = \frac{Debtors}{\frac{Operating\ revenue}{(Turnover)}} * 360$$





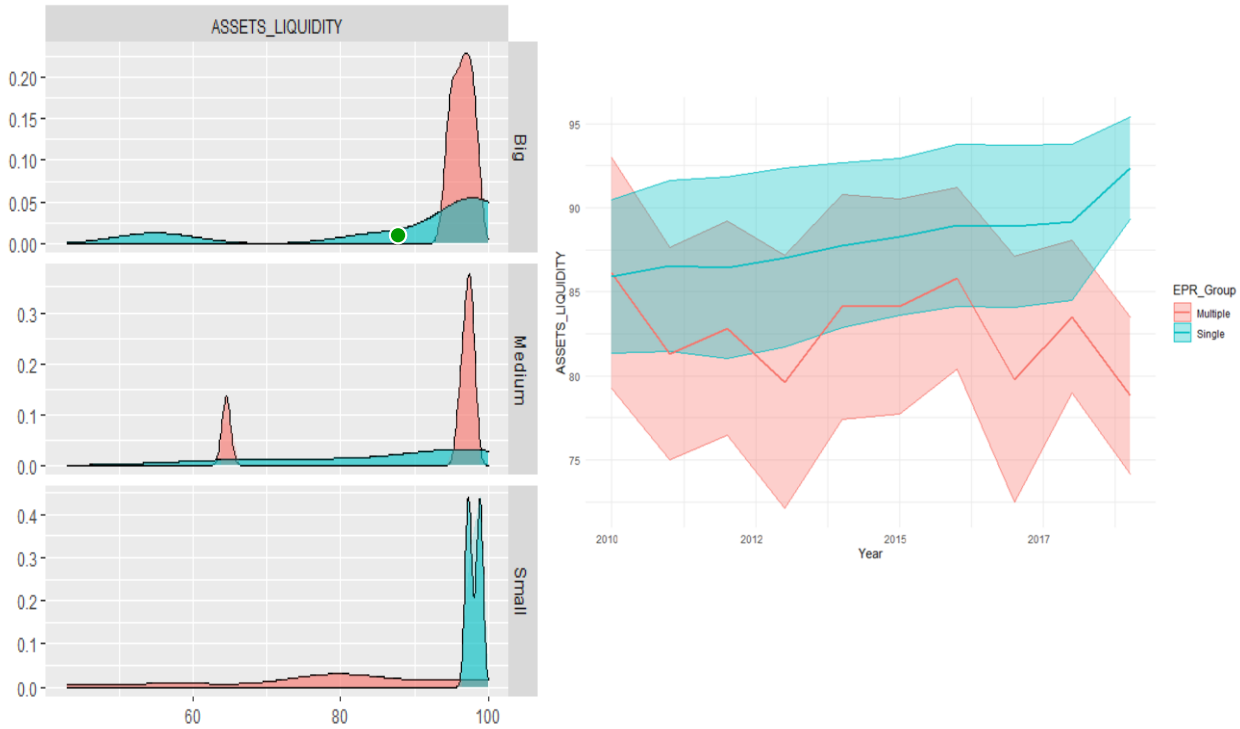
$$Current\ ratio = \frac{Current\ assets}{Current\ liabilities}$$





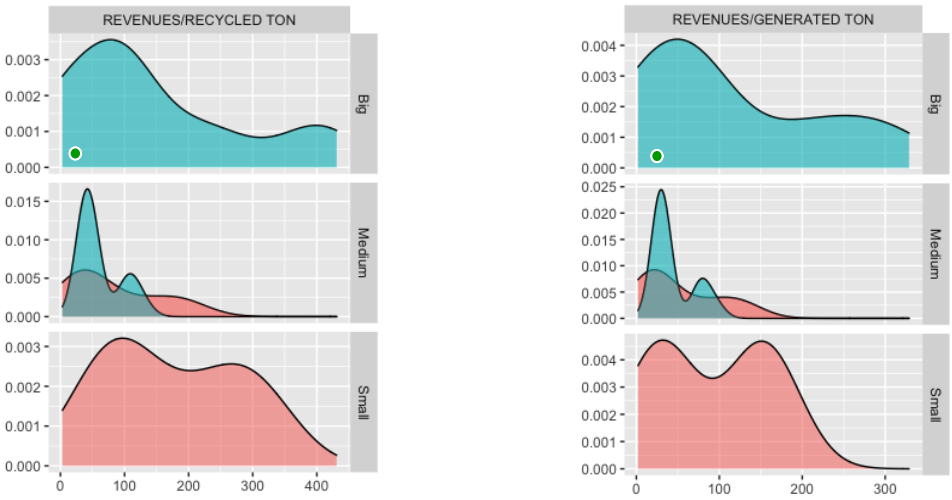
Liquidity

$$Asset\ liquidity = \frac{Current\ asset}{Total\ assets}\ \%$$



Productivity

$$\frac{Operating\ revenue\ (Turnover)}{Recycled\ or\ Generated\ tons}$$



Annex V - Screening the efficiency of packaging waste management in Europe: *tariff schemes*

Authors:

Henning Wilts
Jennifer Schinkel
Stefano Turrini

Note: The PROs were assured that their data will be treated confidentially and only be shared with the research partners at Bocconi University as well as CONAI for evaluation purposes and will only be published in anonymized form.

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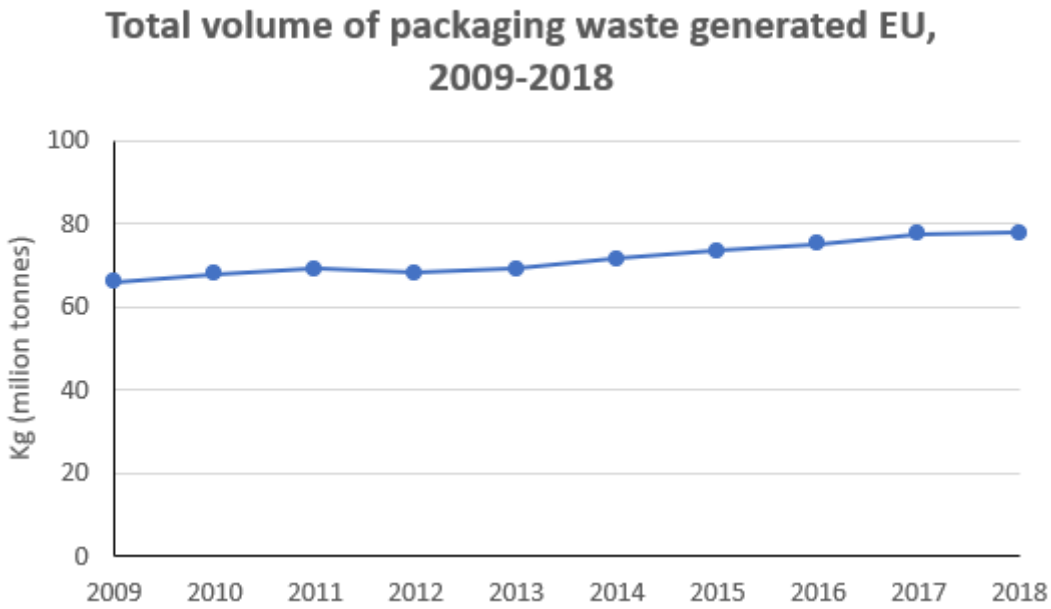
1 Background

Despite raising public awareness for environmental impacts, packaging waste generation in Europe has steadily increased. Nevertheless, despite technical opportunities and political backing, an actual turnaround cannot be observed; massive path dependencies lead to insufficient economic incentives in order to change the deeply routed "make-take-dispose" patterns. A convincing and plausible future vision for packaging is lacking. Insights for such a target knowledge would also be the necessary basis for the development of effective and efficient policy instruments. Especially the economic perspective on waste prevention is so far underdeveloped – with very little publicly available information on costs for implementing waste preventing packaging solutions.
Against this background, the aim of the project is thus to identify and assess the performance of different packaging waste Extended Producer Responsibility (EPR) systems across Europe, focusing on the activities conducted by the Producer Responsibility Organizations (PRO). As a specific part of this project, this report focuses on the analysis of the heterogeneity of tariff schemes in the different European countries, analysing both which factors influence the price level of the fees charged by PROs to packaging producers and how waste collection management is carried out in the different schemes. To collect this information, a survey was developed, conducted among EXPRA members and other PROs, and subsequently analyzed. In addition, supplementary literature on extended producer responsibility in the packaging sector in Europe was studied. Based on this overview the report draws conclusions on options to improve the efficiency of packaging waste management e.g. with regard to the eco-modulation of licensing fees.
Chapter 1 provides a brief background to the EPR framework for packaging in Europe. An analysis of the feedback from the questionnaire follows in chapter 2. The results are then translated into conclusions in chapter 4. The annex includes the questionnaire as well as more detailed answers to specific questions of the questionnaire.

1.1 EPR Framework in Europe

In 2009, the total amount of packaging waste generated in Europe was estimated at around 66 million tonnes (150 kg per capita). Chart 1 shows that Europe has seen an increase in packaging production over the years, reaching 77.7 million tonnes in 2018 (174 kg per capita) (Eurostat, 2020a).

Figure 12: Total volume of packaging waste generated in the EU, 2009–2018



Source: own illustration; data adapted from Eurostat, 2020a

To counter the phenomenon of increasing waste, including packaging waste, and transform its linear economy into a Circular Economy, the European Union has introduced several environmental policy instruments, such as Extended Producer Responsibility. According to the OECD definition, EPR is "*an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer phase of the product's life cycle*" (OECD, 2001). In practice, EPR implies that producers take responsibility for collecting or taking back used goods and for sorting and processing their eventual recycling, thus shifting the responsibility and costs of the negative environmental externalities of products from taxpayers to producers, in line with the "polluter pays" principle (Monier. et al., 2014). The objectives of the EPR are to provide incentives for manufacturers to design more resource-efficient and environmentally friendly products, the reduction of waste and the increase of the recycling activities (Watkins et al., 2017). Given the scarcity of data, mainly due to the lack of transparency between the various EPR systems, the literature review in this chapter is mainly based on studies published by European organisations and on regulations issued by European institutions. At the European level, waste legislation currently provides a comprehensive framework for the implementation of EPR. First with Directive 94/62/EC on packaging and packaging waste, then with Directive 2008/98/EC, which clarified that it is up to each Member State to decide whether the costs of waste management are partly or wholly borne by the producer from whom the waste originates and that distributors of such products may share these costs (Art. 14(2)). In this scenario, member states may take legislative or non-legislative measures to ensure that those who professionally develop, manufacture, own, handle, sell or import products are held responsible in the post-consumer phase of the product. Such measures may include acceptance of returned products and waste that remains after these products have been used, as well as subsequent waste management and financial responsibility for similar activities. They may also include the obligation to provide direct information to the public about the reuse and recyclability of the product (art. 8) (European Parliament and Council, 2008).
Finally, the Circular Economy Package approved in 2018 and consisting of directives number 849 to 852 of the same year, made significant innovations in this framework, setting the recycling target of 65% for municipal waste and 70% for packaging (with minimum recycling targets for each specific type of packaging) set for 2030. In addition, it concretized the economic commitment

required from producers who will have to bear the full cost of separate collection and recovery, thus relieving the public service. Thus, in the new regime, it is up to producers to pay the full cost of all separately collected services, while the public service will only bear the costs of managing the remaining undifferentiated part (the national legislator may also provide that producers also bear the costs of the undifferentiated fraction) (Massarutto, 2019).

1.2 National EPR schemes in the EU

While EU legislation provides the enabling framework, national legislation in the Member States defines the operational and technical aspects of EPR schemes. In Europe, there are various types of EPR schemes, both mandatory and voluntary, which impose an organizational, financial or reporting responsibility on producers. The approach is implemented through a number of different schemes such as take-back requirements, deposit refund systems (DRS) and advance disposal fees (ADF). The former involve setting mandatory or voluntary recycling and collection targets for specific products and assign responsibility to manufacturers or retailers for end-of-life management. The latter charge a surcharge on products in the form of a deposit, which is refunded when the packaging is returned, while ADFs are taxes that are levied on products calculated on estimates for financing the post-use phase of the product. Several countries adopt a combination of these systems, as it is considered more efficient than adopting policies based on a single instrument (Kaffine et al. 2015).
The imposed responsibility can be individual, when a producer is responsible for its own products, or collective, when producers of the same product group pay a variable or a fixed fee for participating in a PRO. A PRO is generally an organization set up by producers that takes responsibility for carrying out recovery and recycling practices on behalf of its members. In recent years, thanks to these organizations, the amount of waste managed and recycled has increased, developing, on the one hand, the infrastructure for the proper treatment of different types of waste and on the other hand contributing to the generation of high quality secondary raw materials and its related markets.
Most of the EU Member States have some form of EPR in place for packaging waste. Many of these schemes have been in place since the 1990s such as in Germany, France, Austria, Belgium, Luxembourg, Sweden, Spain, Portugal, Hungary, Finland and Ireland. Table 2 shows when EPR schemes for packaging were introduced in the different European countries. The most spread approach in the existing EPR schemes in Europe is the take-back requirements. In addition, most European countries have mixed (individual and collective) EPR schemes. For example, Italy has adopted a single collective EPR scheme by creating the PRO CONAI (created on the basis of the 1997 Ronchi Decree), Denmark and Hungary have government-run systems, nine countries have decided to adopt more than one EPR scheme and 12 countries have adopted only a single scheme (Watkins et al., 2017).
Table 2: Start date of EPR schemes for packaging

Member State	Start date of EPR scheme(s)	Collective or individual	If collective, number of EPR schemes
AT	1993	Both	6
BE	1994	Both	2
BG	2004	Both	1
CY	2006	Both	1
CZ	2002	Both	1
DE	1990	Both	9
DK	Government-led scheme		
EE	2004	Both	4
ES	1996	Both	2
FI	1997	Both	N/A
FR	1992	Both	1
GR	2001	Both	N/A
HU	Government-led scheme		
HR	2006	N/a	N/A
IE	1997	Both	1
IT	1997	Collective	1
LT	2002	Both	1
LU	1995	Both	1
LV	2000	Both	N/A
MT	2005	Both	1
NL	2013	Both	1
PL	2000	Both	1
PT	1996	Both	1
RO	2004	Both	7
SE	N/A	Collective deposit system; collective and individual system for other packaging	1 + several deposit systems
SI	2003	Both	4
SK	2003	Both	11
UK	1997	Both	22

Source: Monier. et al., 2014

The type of responsibility held by PROs is also different. In some cases, there is only a simple financial responsibility, i.e. the packaging waste collection and treatment systems are financed by the fees paid by producers to their PRO. An example is the Belgian PRO VAL-I-PAC for industrial packaging. In other situations, such as the systems applied in Spain, Austria, Sweden, Czech Republic and France, where the financial responsibility takes place through direct reimbursement contracts with municipalities, which have taken over the management of packaging waste or directly with sorting facilities. Under other schemes, PROs have partial or full operational responsibility, i.e. they are directly responsible for the take-back schemes and waste processing.

Examples include the Belgian FOST-PLUS scheme for household packaging which has partial operational responsibility, whilst the Austrian ARA scheme and German schemes have full operational responsibility. As indicated in Table 3, PROs may treat packaging waste originating from households, from commercial/industrial activities or, like most PROs, from both of the above (Watkins et al., 2017).

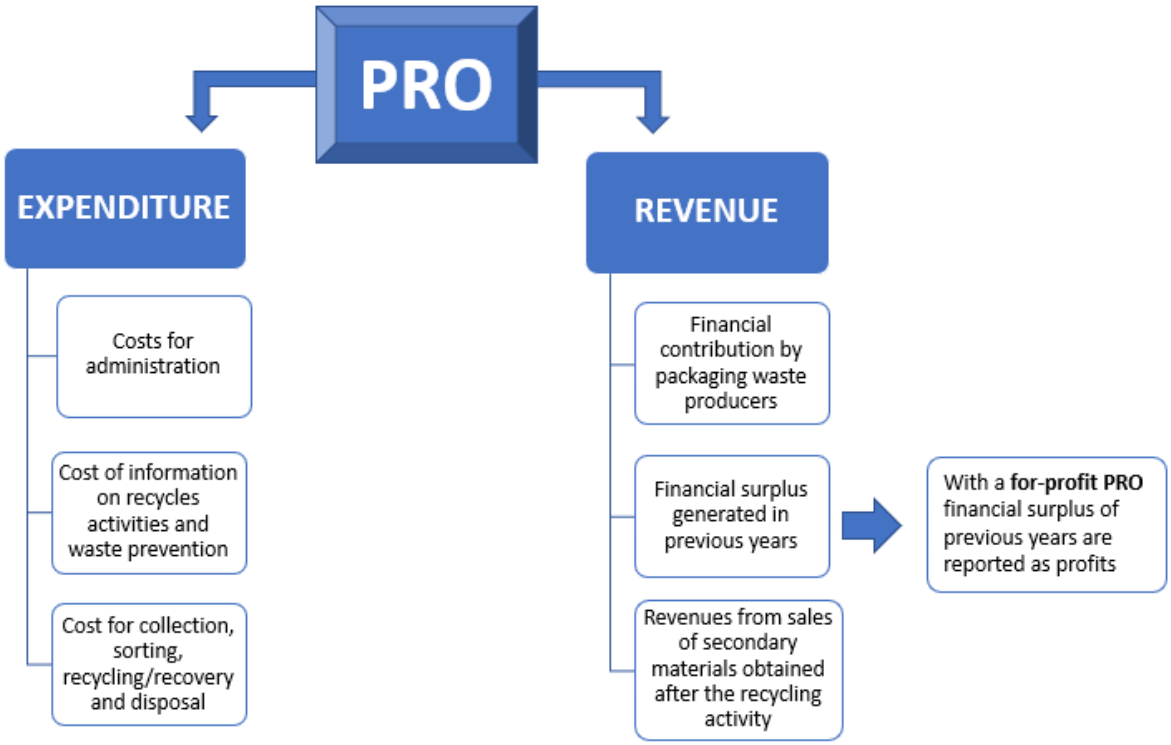
Table 3: Categories of packaging covered by EU EPR schemes

Household (H)/equivalent packaging only	Commercial (C)/industrial (I) packaging only	H and C/I packaging
Belgium: Fost-Plus **France:** CITEO (previously Eco-Emballages) **Germany:** Der Grüne Punkt - Duales System Deutschland GmbH **Spain:** ECOEMBES (will accept commercial/industrial under voluntary agreement if local entities collect it)	**Belgium:** VAL-I-PAC	**Austria:** ARA **Bulgaria:** Ecopack **Cyprus:** Green Dot Cyprus **Czech Republic:** EKO-KOM **Estonia:** ETO **Finland:** Finnish Packaging Recycling RINKI Ltd **Greece:** Hellenic Recovery Recycling Corporation **Hungary:** ÖKO-Pannon **Ireland:** Repak **Italy:** CONAI **Latvia:** Latvijas Zaļais punkts **Lithuania:** Žaliasis taškas **Luxembourg:** Valorlux **Malta:** Greenpak **Netherlands:** Afvalfonds Verpakkingen **Poland:** Rekopol **Portugal:** Sociedade Ponto Verde **Romania:** ECO - ROM AMBALAJE **Slovakia:** ENVI-PAK **Slovenia:** Slopak **Sweden:** FTI **UK**

Source: Watkins et al., 2017

The fees paid by packaging waste producers to PROs have to cover all costs incurred, which include, on one hand, collection, sorting and recycling costs, on the other administrative and information costs related to recycling and prevention activities. The level of these fees in Europe varies from country to country and usually, only non-profit PROs publish these values, as opposed to those that operate in competition with each other. The total amount that these companies are obliged to pay to PROs is complementary to the sale of secondary materials obtained after the recycling activity and any possible financial surplus generated in previous years (with a profit-making PRO, financial surpluses are classified as profits and not allocated to the following year) (Figure 13) (PREVENT Waste Alliance, 2020a).

Figure 13: Expenditure and Revenue for a non Profit PRO



Source: Own illustration based on PREVENT Waste Alliance, 2020a

European PROs have different fees depending on the packaging material placed on the market. Watkins et al. (2017) showed that e.g. fees for plastics tend to be higher than those for other packaging materials such as paper, glass and metals. In addition, some schemes have different specific fees for different types of plastic packaging, with PET/HDPE being one of the cheapest plastic packaging materials because it is the most commonly selected. It is important to say that this can differ between schemes adopted by countries because it tends to reflect the development of sorting and recycling infrastructure available in each country. In addition, a handful of schemes have lower tariffs for bioplastics or biodegradable plastics than for other plastics (Austria, Germany, Latvia and the Netherlands), although these materials do not yet have clear processing and recycling routes defined.
Figure 14 shows how the fees can vary for different countries and materials.

Figure 14: Fees per tonne in 2020

Packaging type	Belgium	France	Netherlands	Spain
Paper packaging	€59.40	€165.30	€22.00	€76.00
Glass	€40.30	€13.50	€56.00	€24.51[1)]
Beverage cartons	€574.00	€246.10	€380.00	€355.00
Plastic bottles	€246.10[1)]	€288.80[1)]	DRS: €20.00 or €0.25 per bottle, otherwise €600.00 or €340.00[1)2)3)]	€433.00[2)]
Recyclable plastics	€357.80[2)]	€309.20 – €485.70[2)]	€340.00[2)]	€377.00[3)]
Other plastics	€711.20[3) 4)]		€600.00[3)]	€739.00[4)]

Source: PREVENT Waste Alliance, 2020a

In recent years, particular attention has been paid to the eco-modulation of fees as it is seen as a powerful tool to influence the way products are conceived, designed and manufactured. In countries such as the Czech Republic no fees are charged for reusable packaging, in France, where the CITEO system is in operation, fees are reduced if the amount of material in the packaging is reduced and if it is recyclable. In addition, fees are higher for packaging made of materials that cannot be recycled or recovered. In Italy, the CONAI system applies fees based on recyclability and weight of materials (regarding weight, it is important that this reduction is not at the expense of the recyclability of the whole packaging) (Watkins et al., 2017).

2 Survey on packaging waste management in Europe

To obtain information on the heterogeneity of tariff schemes across countries, the Wuppertal Institute has developed a questionnaire in coordination with the project lead Bocconi University. The questionnaire can be found in the appendix. It was sent on 29.1.2021 respectively 1.2.2021 to 44 PROs, thereof 23 EXPRA members and 21 further PROs. A reminder was sent by the Wuppertal Institute on 15.2.2021 and another to selected PROs on 15.3.2021 by Joachim Quoden, Managing Director of EXPRA. The PROs were assured that the data will be treated confidentially and only be shared with the research partners at Bocconi University as well as CONAI for evaluation purposes and will only be published in anonymized form.

2.1 Responses

As of 31.3.3021 we received 28 responses, of which 14 returned the questionnaire fully or partially completed (Table 4). 7 PROs did not fill out the questionnaire, but sent us partial information. 4 PROs completely declined to participate and 3 told us that they were willing to participate, but we did not receive any data up to this point. A detailed list of the feedback from the PROs can be found in Table 5. The reasons given by the PROs who did not complete the questionnaire or refused to participate are listed in Table 6.

Table 4: Number of responses to the survey

28 responses	
questionnaire received	14
willing to participate (waiting for data)	3
no questionnaire, but data	7
participation declined	4

Table 5: Responses to the survey by the PROs

Questionnaire received by PROs from 14 countries	
Czech Republic: EKO-KOM	Ireland: Repak
Bosnia & Herzegovina: EKOPAK	Luxembourg: VALORLUX
Estonia: ETO	North Macedonia: Pakomak
Finland: FPRR	Romania: ECO-ROM Ambalaje
Germany: Der Grüne Punkt	Slovenia: SLOPAK
Greece: HERRCO	Spain: Ecovidrio
Hungary: ÖKO-Pannon	UK: Valpak
Partial information received from another 7 PROs:	
Austria: ARA	Germany: Landbell
Belgium: Fost-PLUS	Portugal: PONTO VERDE
Belgium: Valipac	Sweden: FTI
Bulgaria: ECOPACK	
Willing to participate (waiting for data)	
Cyprus: GREEN DOT	Spain: ECOEMBES
France: CITEO	

Table 6: Reasons given by PROs who declined to participate

Reasons of the PROs who did not complete the questionnaire or refused to participate
• requested information is **sensitive**/not freely available • it is not possible to share it with a third party • very **confidential** information is requested • protection of **business secrets** • does not share/publish its fees since they're considered a trade secret and are set **individually for each client** • **competitor** on the Italian market • current **workload**

2.2 Analysis of the survey

The questionnaire consists of 4 parts with a total of 7 questions:

1 | Costs and operational responsibility
2 | Generation and collection
3 | Tariffs for packaging material put on the market

4 | Tariffs for packaging material collected and recovered.

This report focuses on the answers to part 3 and 4, while the responses to part 1 and 2 are also documented in this report. Following consultation with Bocconi University and CONAI, questions number 2 respectively 3 were removed from the survey of PROs for which the relevant data were already available. Where they were not yet available, PROs were also asked to provide their fee report and/or financial statement for the latest year available. The questionnaire can be found in the appendix. The completed questionnaires were shared with the research partners at Bocconi University and CONAI.
Due to the number of responses on the one hand and the variety of answers due to the various systems, on the other hand, a reliable quantitative analysis was not feasible. Therefore, a descriptive approach was chosen, accompanied by visualization with diagrams.

2.3 Part 1: Costs and operational responsibility

The first question was to provide a quantification of PRO's costs (in euro or local currency, for 2019 or latest year available) for the collection, sorting and treatment, recycling, recovery or disposal, research and development and communication campaigns. 8 PROs provided data to this question. Due to the different systems and responsibilities of the PROs, the answers are very diverse. Some pointed out that the data requested was only partially compatible with their cost structure and existing data set. Question 2 asked to quantify the revenue of the PROs from the sale of recycled materials and other operational phases.

2.4 Part 2: Generation and collection

Regarding generation and collection, the PROs were asked to provide the generated waste from households and non-households, if applicable (2019 or latest year available). 10 PROs responded to this question by providing data. These data and the methodology with which they are calculated are very diverse across PROs. Appendix III contains charts of the responses for each fraction (glass, paper, plastic, aluminium, steel, wood, recyclable composites; non-recyclable composites are not listed as no PRO provided separate data on them). Additional comments from the PROs have been added.
The subsequent question asked the PROs to describe their packaging collection systems for each material. 13 PROs answered this question; the results are shown in Table 7. The difference is due to the fact that different systems can be in operation for each material.
The PROs were also asked to indicate the year they first implemented each system as well as the last year it was in operation when they stopped using a system. Here we received detailed answers for 5 PROs.
Table 7: Number of PROs using the specified packaging collection systems

Please describe your packaging collection systems for each material.						
	Deposit	Door-to-door (single)	Door-to-door (co-mingled)	Bring points	Civic amenity sites	Other
Glass	2	3	4	12	5	2
Paper	-	4	5	8	5	1
Plastic	2	2	7	7	4	1
Metals	2	2	7	7	4	1
Wood	-	2	3	4	3	2

Source: own illustration based on the survey (n=13; Multiple answers possible)

As shown in Table 7, for glass, bring points are by far the most frequently used packaging collection system, followed by civic amenity sites and door-to-door (co-mingled). Likewise, for paper the most used system is bring points, followed by civic amenity sites and door-to-door (co-mingled). For plastic and metals, bring points and door-to-door (co-mingled) are equal in the responses of the PROs. In the case of wood, bring points were mentioned mainly, but less frequently overall.

2.5 Part 3: Tariffs for packaging material put on the market

The third part of the questionnaire focuses on tariffs for packaging material put on the market. The PROs were asked whether they design their tariff system for packaging material put on the market in a way that promotes material efficiency and/or waste prevention. 13 out of 14 PROs answered this question. Of these, 6 answered with “no”, 4 with “yes”, and 3 PROS indicated that they were planning to implement such a system. Table 7 shows exemplary answers.
The PROs that answered with “no” usually did not give any further explanation. A few responded that their fees are designed to cover only their operational costs because they are non-profit organisations and therefore obliged by law to do so.
Among the PROs that replied "yes," the measures include fees per unit and weight, penalizing heavier packaging and very small packaging. Others impose a surcharge for non-recyclable materials. One system implemented “Packaging Waste Recovery Notes”, by which businesses have to pay fees to promote recycling. This also creates incentives for packaging minimization and lightweighting, as businesses that put more packaging on the market are required to finance the recycling of a greater amount of packaging.
The responses show that incentives for waste prevention and material efficiency usually do not play a role in the design of the tariff systems of the responding PROs. In some cases, these aspects are indirectly promoted by the tariff system. When environmental aspects are considered in the design of tariffs, the focus is typically on recyclability.

In the cases where an approach to promote waste prevention or material efficiency is planned, an eco-modulation approach is indicated. An example of a system already using an eco-modulation approach is described in more detail in chapter 3.1, looking at the French system.

Table 7: Exemplary answers to the question whether PROs design the tariff system in a way that promotes material efficiency and/or waste prevention

Do you design the tariff system for packaging material put on the market in a way that promotes material efficiency and/or waste prevention?			
Yes	▪ Companies pay glass green dot **fee by units and weight** […]. That means that heavier packaging and very small packaging […] are penalized.	▪ Each material bears its costs for collection, sorting and recycling minus the revenue. **Non-recyclable** material gets a surcharge.	▪ […] [Businesses] placing more packaging onto the market are required to fund the recycling of a greater amount of packaging, **incentivising packaging minimisation/lightweighting**.
Planned	▪ Very soon […], we will use the **eco modulation approach** based on material efficiency and waste prevention.	▪ Not yet, **partially for PET and aluminium** that have better prices. In the future, we plan to make the tariff system fully **eco-modulated**.	▪ Recycling fees are determined by the PROs independently. […] **Ecomodulation** will be introduced by amendments to the waste act. For example, for wooden pallets, we already have lower fees if the pallet is **reusable**.
No	▪ There is no connection between the TAX and material efficiency or waste prevention **except for shopping bags**.	▪ Pakomak by the law is a non for profit organisation. The tariffs are designed in order to cover […] all **operational costs** […].	▪ No *(no further explanation)*

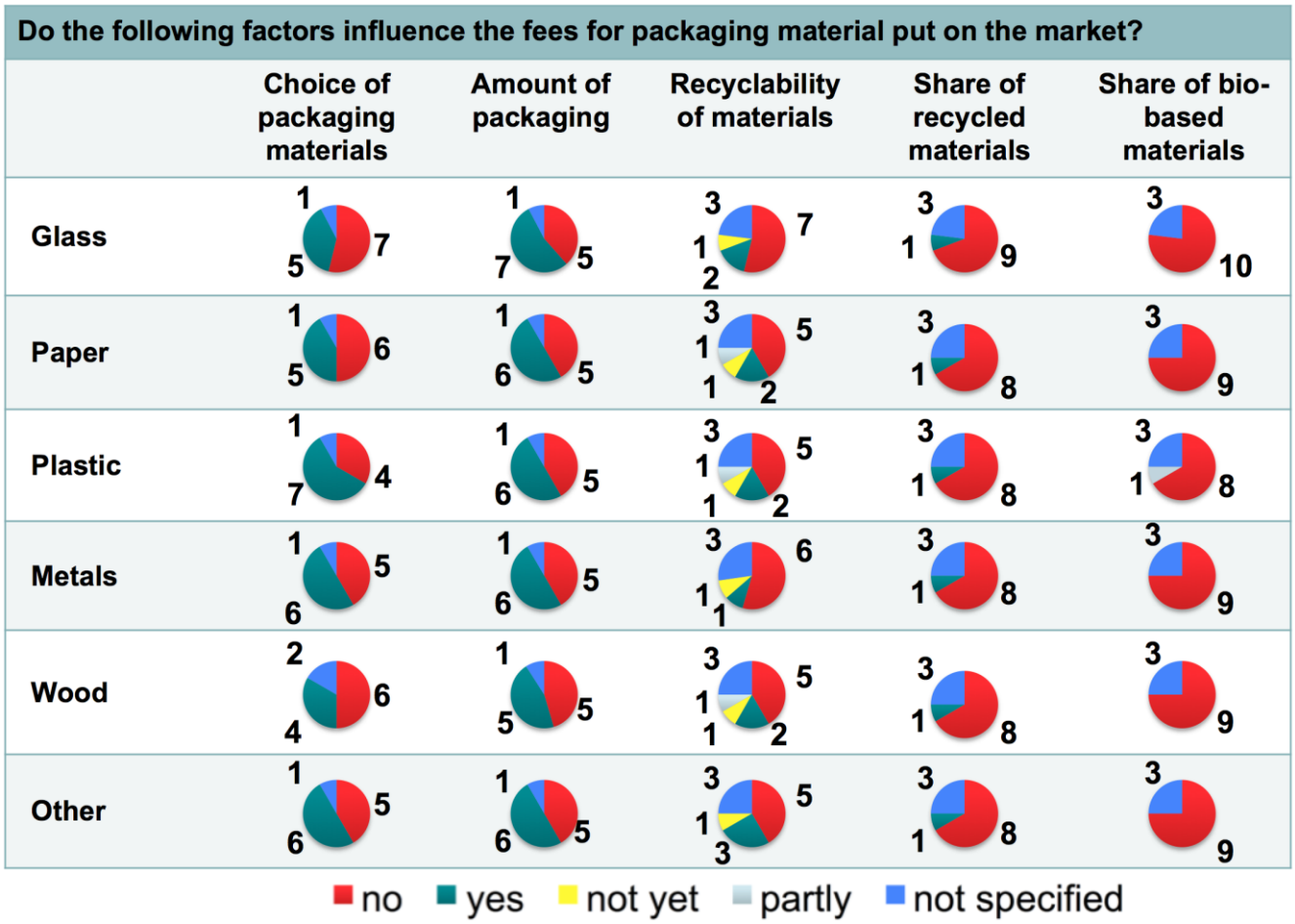
Source: own illustration based on the survey (emphasis added)

The subsequent question addressed whether the following factors (if applicable) influence the fees for packaging material put on the market:

- choice of packaging materials (e.g. use of paper or different types of plastic)
- amount of packaging (volume, weight)
- recyclability of materials
- share of recycled materials
- share of bio-based materials

This question refers to the different types of materials such as glass, paper, plastic, metals, wood and other. Table 8 shows the responses of the PROs. For glass, n=13 as one of the answering PROs only has responsibility for glass. For the other fractions n=12.

Table 8: Factors influencing the fees for packaging material put on the market



Source: own illustration based on the survey (n=12; for glass n=13)

The choice of packaging material is especially important in the case of plastics. For the amount of packaging, the answers are more or less balanced with a slight tendency towards the amount influencing the fees. With regard to recyclability, the majority stated that this does not have an impact on the fees. Only in a few cases it is relevant, partly relevant or planned. The share of recycled materials and the share of bio-based materials play practically no role.

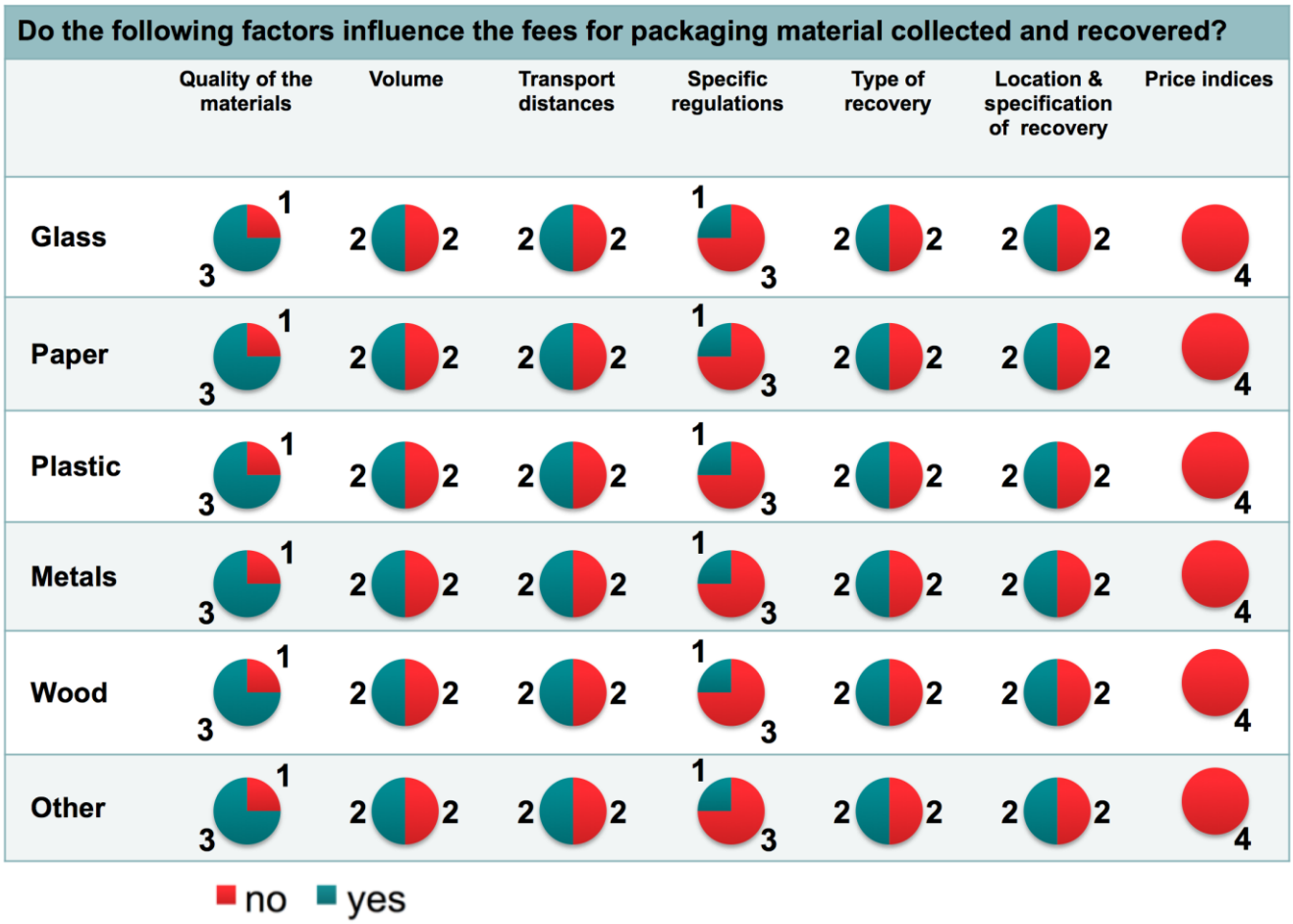
2.6 Part 4: Tariffs for packaging material collected and recovered

The last part of the questionnaire focuses on the tariffs for the collection and recovery of packaging material. The PROs were asked whether the following factors (if applicable) influence the fees for collected and recovered packaging material:

- quality of the materials (e.g. share of pollutants)
- volume (e.g. crushed PET bottles versus big bags of empty bottle)
- transport distances Specific regulations for the hand over of materials
- type of recovery
- location and specification of the recovery operation
- price indices (e.g. ICIS for output materials)

This was again asked for the fractions glass, paper, plastic, metals, wood and other. Table 9 shows the responses of the PROs. The question was answered completely by 4 PROs (n=4), 6 PROs left the form blank for this question, 2 answered "not applicable" in all boxes. The answers of 2 PROs could not be clearly assigned yes or no. These two responses are described in the text below but were not included in the diagrams.

Table 9: Factors influencing the fees for packaging material collected and recovered



Source: own illustration based on the survey (n=4)

Table 9 shows that in most cases, the quality of the material has an influence on the amount of the fees for packaging materials collected and recovered for all types of materials. The PRO's answers on volume, transport distances, type of recovery and location and specification of the recovery facility are balanced between "yes" and "no". Specific regulation has an impact in only one case. Price indices do not affect the fee structure of these PROs. There are no differences in the answers with regard to the individual fractions.
In the cases that were not answered unambiguously, in one case the quality of materials and transport distances were indicated as influencing the fee for plastic and metal. In addition, the volume does not play a role for any of the fractions. In the other case, it was stated with regard to the volume:

> „Fees represent a broad aggregate of the different recycling costs of different materials within the broad materials (e.g. PP has different recycling costs to HDPE, however the plastic fees payable represents an average).“

When asked about price indices in this case, the answer was that the most commonly used public index for UK PRN prices is t2e.co.uk. This PRO further noted:

> "UK Government has proposed to introduce a system of modulated fees for packaging in 2023/24, which would see different packaging materials within the broad material groups likely be subject to different fees. Whilst it is anticipated this modulation system will take into account the varying costs associated with collection and recycling different materials within the broad material categories, at the time of writing the final design of fee modulation system as well as when it will be implemented remain unknown."

3 Practical examples

In the following, three examples of EPR systems are described in more detail:

- The French case of CITEO, which already uses an eco-modulation approach, as some PROs are planning to implement.
- The Spanish case of Ecovidrio with their attempt to improve their efficiency.
- The German case of introducing minimum standards for determining the recyclability of packaging

3.1 France: Citeo's bonus/penalty system

The French system, based on the CITEO PRO, is a collective system for household packaging waste, which promotes the waste hierarchy by encouraging waste prevention and recycling practices. The fee modulation system provides for fee reductions if the products have eco-design features based on environmental criteria, such as if the product is made of a particular type of plastic that is easy to recycle.

From the analysis of the Table 10 emerges that design has been promoted through bonus/malus to be applied to fees. For example, a 50% penalty is applied to specific packaging that cannot be recycled or that hinders the recycling process, or a 100% penalty is applied, both for packaging that cannot be recovered and for those containing mineral opacifiers. On the bonus side, the fee can be reduced by up to 24%. A bonus is given, for instance, if end-of-life sorting instructions are provided; these can be on the packaging itself (with the QR code or with the Triman logo), advertised by the company producing or through awareness-raising initiatives such as the 2015 'Waste sorting day' where the aim was to educate people about the circular economy and packaging waste recycling. Another type of bonus is provided if specific individual points from design guidelines for the EPR system are taken into account. For example, when the weight of the packaging is reduced compared to the original version, if the recyclability of the product is improved and if packaging is produced from materials that have available technology and infrastructure for recycling.

The weight of products in the French system is also an important factor in the modulation of fees because it can influence the amount. As described in chapter 4 (Improving EPR schemes), it is important to combine the resource efficiency benefits of lightweight with the ability of products to be reused and/or recycled and discourage episodes such as the one in the opaque PET, where producers of this material paid less fee based on weight even though the material was not recyclable (Watkins et al., 2017).

Table 10: Eco-modulation of tariffs of the CITEO scheme

BONUS		
Awareness bonus	**On-Pack bonus[1]**	
	8%	Sorting instruction on packaging
	5%	Triman logo on packaging
	4%	QR code that links to a validated sorting instruction
	Off-Pack bonus[2]	
	4%	Off-pack awareness actions (e.g. TV/radio, advertisement, press)
Reduction bonus	**Reduction and recyclability Bonus[3]**	
	8%	≥ 1 action(s) for reduction of packaging or improvement of recyclability
	+ 4%	Additional bonus if the action is documented and published in the catalogue of good practices of CITEO
	Bonus for sortable plastic packaging	
	12%	Bottles in PET, HDPE or PP
	Bonus for hard plastic packaging that can join existing recycling channels	
	8%	Hard packaging that is made out of PET, HDPE or PP (besides bottles)
Total Bonus = awareness bonus + reduction bonus = min. 0% - max. 24%		

MALUS[4]	
Malus for packaging included in sorting instructions, but without a recycling channel	100%
Malus for packaging with mineral opacifiers	100%
Malus for disruptive packaging (damage to recyclability)	50%
Malus for paper and cardboard with mineral oil-based ink	10%

[1] *On-pack bonuses cannot be cumulated.*
[2] *Off-Pack bonus can be cumulated with On-Pack bonus; the maximum awareness bonus is thus 12%.*
[3] *This bonus can only be applied the first year the packaging is brought on the market.*
[4] *Packaging that is subject to a malus cannot benefit from a bonus.*

Source: Watkins et al., 2017

3.2 Spain: Ecovidrio's solution to make the system more efficient

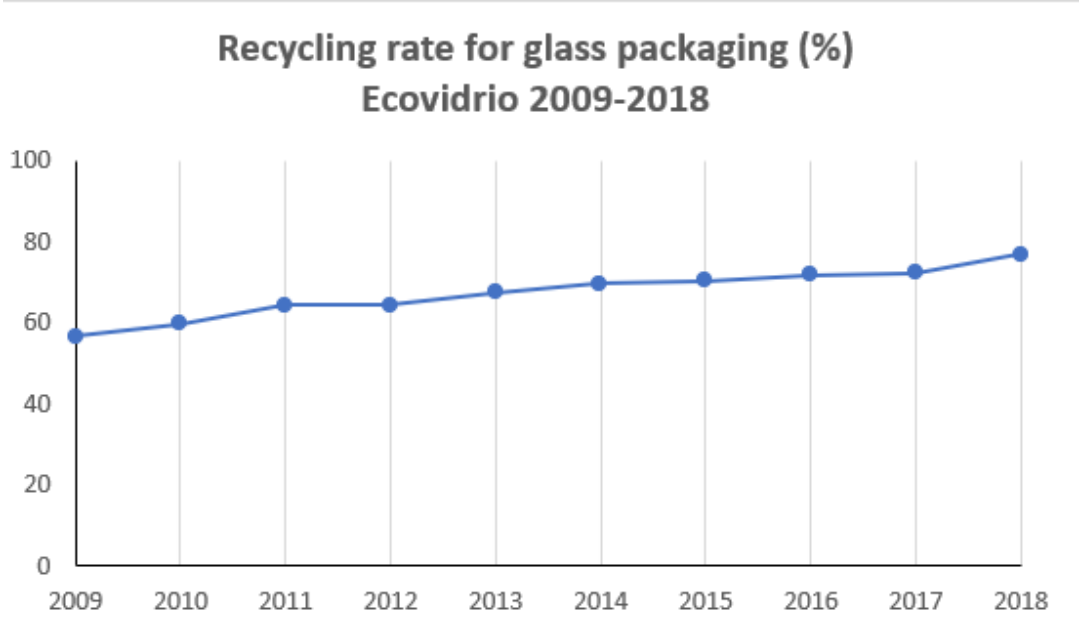
Another example is Ecovidrio, a PRO financed by glass packaging companies and responsible for glass recycling throughout Spain. This PRO, in addition to having fees that are influenced by the weight of the material, as to incentivize lighter products acting in coherence with the waste hierarchy, where waste prevention comes first, has estimated that the "Horeca" sector (abbreviation of the words Hotel/Restaurant/Catering) generates 52% of single-use glass packaging waste in Spain. In order to make the collection service for glass packaging materials to this category more efficient, it has designed special bins with self-emptying mechanisms that help professionals recycle a large amount of waste quickly and safely. These bins are equipped with two systems called "Autovolcado" (Figure 15) and "Ale Hop" (Ecovidrio, 2020). In recent years, the share of recycled materials has increased, as shown in Figure 5 (Eurostat, 2020b). The message behind this best practice is that each PRO should analyze the composition of its internal market and design services and new technologies to facilitate all stages of waste management from

collection by economic actors to final treatment at the appropriate infrastructure, making the system more efficient.

Figure 15: Ecovidrio Autovolcado System

Source: La Voz de Asturias, 2018

Figure 16: Recycling rate for glass packaging, Ecovidrio 2009–2018



Source: Own illustration, data adapted from Eurostat, 2020b

3.3 Germany: Minimum standards for determining the recyclability of packaging

Germany was one of the first countries to set up an Extended Producer Responsibility system for packaging. In 2003, a new system consisting of several for-profit PROs operating in competition with each other was adopted, compared to the previous one based on a single non-profit PRO. In January 2019, a new Packaging Act (Verpackungsgesetz)[13] came into force, which among its innovations set: on the one hand, as shown in Table 11, an increase in the recycling targets for all

[13] https://www.gesetze-im-internet.de/verpackg/index.html#BJNR223410017BJNE001700000

types of material for the year 2022, compared to 2018, and on the other hand, it took into account the recyclability of packaging when setting EPR tariffs (PREVENT Waste Alliance, 2020b).

Table 11: Germany's new recycling targets

Material	Target under the Packaging Ordinance (applied up to the end of 2018)	Target as of 1 January 2019	Target as of 1 January 2022
Glass	75%	80% ✓	90%
Paper, cartons and cardboard	70%	85% ✓	90%
Ferrous metals	70%	80% ✓	90%
Aluminium	60%	80% ✓	90%
Beverage cartons	60%	75% ✓	80%
Other composites		55%	70%
Plastics	60%	90%	90%
Mechanical recycling (plastics)	36% ✓	58.5%	63%

✓ target has already been met

Source: PREVENT Waste Alliance, 2020b

Section 21 of the Packaging Act states that, when calculating the participation fees which companies pay to the various PROs, the latter are obliged to create economic incentives to promote:

1 | the use of materials that can be recycled at the highest possible percentage rate, taking into account sorting and recycling practice
2 | the use of secondary materials and renewable raw materials.

The basis for assessing recyclability is defined as the suitability of packaging to replace virgin material in typical applications after having been subject to recovery processes and includes all packaging components such as labels, sealing films, lids and closures etc.
To measure recyclability, 3 requirements have to be taken into account:

3 | The presence of sorting and recycling infrastructures on the national market that allow for high-quality mechanical recycling of materials.
4 | The sortability and separability of packaging and its components
5 | The incompatibility of packaging components or substances contained in the packaging that may hinder recycling (e.g. coatings, insoluble adhesives, etc.) (Hogg et al., 2020).

To ensure a uniform framework for determining recyclability, section 21 provides for the annual publication of minimum standards by the Central Agency Packaging Register (Zentrale Stelle Verpackungsregister) in agreement with the German Environment Agency (Umweltbundesamt). The Packaging Act does not set legal specifications for increasing or decreasing charges due to the recyclability of packaging, because they could not be specified in a generally binding way and, moreover, this would be a significant violation of the freedom of systems to set prices, which is protected by the German antitrust law (Zentrale Stelle Verpackungsregister, 2020). The PROs have to report annually, how they have determined recyclability in compliance with the minimum standard and how they have used it as a basis for calculating their fees (Umweltbundesamt, 2020).

4 Conclusions

The objective of this report and the survey was to examine the heterogeneity of EPR tariff schemes on packaging waste and whether PROs provide incentives to reduce packaging waste for example by rewarding waste prevention or recyclability of materials.

Findings of the survey

One finding of the survey is that the data situation remains poor and inconsistent. Although several PROs shared their data openly and with engagement, some PROs refer to business secrets and state that they cannot share data, e.g. for Multiple reasons. Others did not provide any feedback. Another challenge is the variety of systems, which makes it difficult to compare data. Different methodologies of data recording exist, and in some cases the data requested is not collected separately or not collected at all.

Despite the lack of representative data, it is nevertheless possible to draw a number of conclusions regarding the design of the fees:

Some PROs state they already promote material efficiency and/or waste prevention through their fees for packaging put on the market. Others are planning an eco modulation approach. Some, however, have no plans in this direction or design their fees just to cover operational costs. In some cases, they have concerns about legal challenges. Here, it should be examined whether there are actually no possibilities to modulate fees within the national legislation so far or whether the framework conditions need to be adapted.

The European Waste Framework Directive encourages EU member states to modulate their fees within the EPR "by taking into account their durability, reparability, re-usability and recyclability and the presence of hazardous substances, thereby taking a life-cycle approach […]" (European Parliament and Council, 2018). From the questionnaire, we could determine that regarding the fees for packaging put on the market to some extent the choice of packaging is relevant, while recyclability of materials and the share of recycled materials hardly play a role. These are important elements, that should be considered stronger in the modulation of fees to foster recyclability already in the design phase and increase the share of recyclate, thus making an active contribution to waste prevention through pricing. Nevertheless, the choice of packaging materials and the amount of packaging are not yet addressed in all cases. Therefore, also these factors are still an important variable that can be expanded.

Regarding the factors influencing the fees for collected and recovered packaging material, there is little data available from the questionnaires. However, the answers show that especially the quality of materials is relevant for pricing, which is beneficial in terms of circularity. Meanwhile, other factors are not comprehensively addressed, showing that there is still extensive potential for improvement to ensure a more circular path for the waste system.

In the following, suggestions for future incentives as well as specific conclusions on the modulation of fees are given.

Fee modulation

The different EPR systems that are currently active in Europe present various criticalities, such as the lack of transparency of PROs data, the implementation of heterogeneous schemes and the lack of tariffs linked to packaging designed with durability, reusability, repairability and recyclability in mind. Watkins et al. (2017) recommend the following regarding fee modulation:
Fee modulation is probably the strongest incentive to encourage eco-design and thus support the waste hierarchy. It is essential to implement a fee system that incentivizes eco-design through a concessional level of taxation, which significantly influences the level of material fees, otherwise the risk is that these only serve to cover the costs of waste management. These factors are:

- *Level of recyclability of the packaging material:* When assessing the recyclability of packaging, it is important to take into account some factors such as the presence of technology suitable for the recycling of that particular type of material, that the design of the packaging is suitable for the recycling process and that the chemical composition of the packaging is not composed of several materials, as in the case of plastics where the combination of several polymers hinders the recycling process.
- *Level of product reuse:* products designed for reuse should be taxed more favourably
- *Amount of recycled content of packaging:* this has the potential to develop new markets for secondary raw materials.
- *Level of virgin material:* making the use of virgin material more expensive is intended to increase the demand for recycled materials and feed the demand for them into secondary markets
- *Weight of packaging material:* It is important to combine the resource efficiency benefits of lightweight with the ability of products to be reused and/or recycled. However, lighter products are not always recycled, therefore, it is important not to facilitate non-recyclable but lightweight products, as in the case of French opaque PET, where producers of this material paid less fee based on weight even though the material was not recyclable.

Improving EPR schemes

As the analysis of the survey showed, in recent years EU EPR policies have been developed and implemented in a very heterogeneous way, making it difficult to compare different EPRs, as the technical conditions for recycling such as its management and measurement procedures are different. Also, the performance of eco-design, at the national level, is impossible to evaluate systematically and the real costs of PROs are considered sensitive data as they are part of "business secrets" and therefore rarely shared. This lack of transparency hinders the comparison of the activities of the various PROs making it difficult to measure the effectiveness and efficiency of current EPR schemes in Europe (Watkins et al., 2017). It is up to the European Union to define the EPR system in more precise terms allowing for the harmonisation of the various schemes currently operating in different member countries.
What is required is greater sharing of data calculated using the same procedures in both collective and individual EPRs. Furthermore, in the first, tariff modulation is more relevant than in the second, because on the one hand there is a greater possibility to differentiate the products of member producers, thus offering more possibilities for tariff modulation to have an impact on eco-design. On the other hand, it avoids the phenomenon of mutualisation of responsibilities of many

different individual producers, which leads to the risk of "averaging" costs between producers, thus discouraging individual eco-design efforts.
In the current tariff systems for packaging placed on the market and for packaging collected and recovered, factors such as the type of material used, the volume, weight and recyclability of the packaging for the former and the volume, weight and type of recovery for the latter, are only sometimes taken into account. The key element that needs to be developed at the European level to encourage waste prevention is eco-design. It involves aspects such as the design of materials that are reusable with the same primary function, lighter in weight (without affecting recyclability) and the development of new technologies, which make production systems more efficient, due to the lower amount of material used. In addition, where prevention is not possible, ecodesign must focus on recycling, with favourable rates for 100% recyclable packaging and for packaging with recycled content, thus enabling the development of markets for secondary materials (Watkins et al., 2017).
In conclusion, current EPR systems largely operate around the element of recycling and as such, it is preferable to final disposal and incineration (with or without energy recovery) of waste. However, it should be noted that prevention and re-use are the preferred options according to the waste hierarchy and therefore these schemes should be designed in such a way as to encourage these types of actions. The EPR is therefore a vital part of the framework to ensure that the value of packaging waste remains within the economic system and the design of specific waste reduction and recycling fees are the tools to make this happen.
It is also in the interest of PROs to contribute recommendations from the practice to this process and to support it by providing data so that the specifications can be made on a solid basis and are not imposed externally.